THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. X.

No. XI.—NOVEMBER, 1903.

ORIGINAL ARTICLES.

I.—Notes on some specimens of Straight-shelled Nautiloidea collected by the Rev. Samuel Couling, M.A., Ching Chow fu, Kiaochow, North China.

By G. C. Crick, Assoc.R.S.M., F.G.S., of the British Museum (Natural History).

(PLATE XXII.)

THE specimens, etc., upon which the following notes are based were sent from China by the Rev. Samuel Couling, M.A., to Dr. Henry Woodward, F.R.S., who has kindly permitted me to examine them. They consist of two examples displayed in longitudinal section upon the surface of two blocks of limestone, and photographs of three other examples, together with the rubbing of a fourth similarly preserved.

"The locality from which the fossils come is found in Richthofen's Atlas [von China], West Shantung plate, south of Tsing tshou fu, 36° 40′ N. Lat., 118° 40′ E. Long. The hills are marked Mittel and Ober Sinisch" (i.e. between Cambrian and Silurian in age).

The specimens belong to the straight-shelled Nautiloidea, and represent at least three distinct species.

One of these is indicated on the weathered surface of a slab of grey limestone by a longitudinal section showing a nummuloidal siphuncle, and, towards the posterior part of the specimen, three or four chambers. A length of about 95 mm. is preserved and is entirely septate; the shell apparently tapers very slowly; its greatest width is about 50 mm., the siphuncular elements here being about 24 mm. and the depth of the chambers 11 mm. Obstruction rings (*anneaux obstructeurs*) are well developed, contracting the central axis of the siphuncle into an annulated endosiphuncle with tubules radiating from the annulations. The openings of these tubules are well shown in several of the siphuncular elements at the upper part of the specimen. The relative proportions of this specimen resemble those of the posterior portion of Barrande's *Orthoceras docens*,[1] occurring in the Silurian of Bohemia, in Étage E,

[1] J. Barrande: Bull. Soc. Géol. France, sér. II, tom. xii, p. 453, pl. xii A, figs. 2, 3; and Syst. Sil. Bohême, vol. ii, texte iii (1874), p. 632, pl. ccl.

bande e_2, which is regarded as the equivalent of the Wenlock and Ludlow of this country (see Fig. 1). In that species the siphuncular elements decrease in diameter towards the body-chamber.[1] They appear to do the same in the present specimen, but this, I think, is due to the fact that the anterior part of the specimen is weathered down further from the median axis than the posterior part.

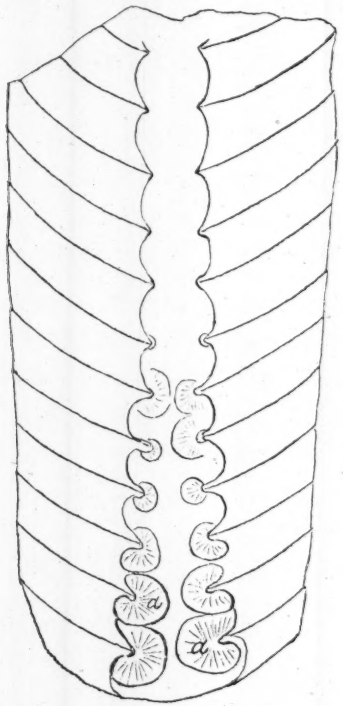


Fig. 1.—Longitudinal section of *Actinoceras* (*Paractinoceras*) *docens*, J. Barrande, sp. *a*, *a*, organic deposits upon the necks of the septa, forming obstruction rings (*anneaux obstructeurs*). Silurian (Étage E, bande e_2): Dworetz, Bohemia. (After Foord.)

The specimen may, I think, safely be referred to Stokes's genus *Ormoceras*,[2] a genus confined to the Ordovician rocks of North America and now regarded as a subgenus of *Actinoceras*;[3] and I would suggest that it is nearly allied to Hall's *Ormoceras tenuifilum*,[4]

[1] Foord (Cat. Foss. Ceph. British Museum, pt. i, 1888, p. 208, fig. 32) referred Barrande's species to Hyatt's genus *Sactoceras* (Proc. Boston Soc. Nat. Hist., vol. xxii, 1883, p. 273), but Hyatt himself, in Eastmann's translation of Zittel's "Textbook of Palæontology" (p. 528, fig. 1080), refers the species to *Paractinoceras*, a new subgenus of *Actinoceras*.

[2] C. Stokes: Trans. Geol. Soc. [2], vol. v, pt. 3 (1840), p. 709.

[3] A. Hyatt in Eastmann's Translation of Zittel's "Textbook of Palæontology," vol. i (1900), p. 528.

[4] J. Hall: Nat. Hist. New York, pt. vi, Palæontology, vol. i (1848), p. 55, pl. xv, figs. 1*a*-*e*; pl. xvi, figs. 1*a*-*e*; pl. xvii, figs. 1*a*, *b*. See also J. Barrande: Syst. Sil. Bohême, vol. ii, pl. ccxxxvii, figs. 5–7.

a common species in the Black River Limestone (Ordovician) of New York State.

The original of Fig. C in our Plate XXII is referable to the same genus, and possibly also to the same species.

It is of interest to mention that the matrix contains several small Brachiopods respecting which Mr. Buckman (who kindly examined them at Dr. Woodward's request) says, "The general appearance suggests *Orthis* (*Dalmanella*) *testudinaria*, Dalman, an Ordovician species."

A second species is represented by a photograph of a section of a fragment (Plate XXII, Fig. B), and a rubbing of another specimen about 25 centimetres long, displayed in section on the surface of

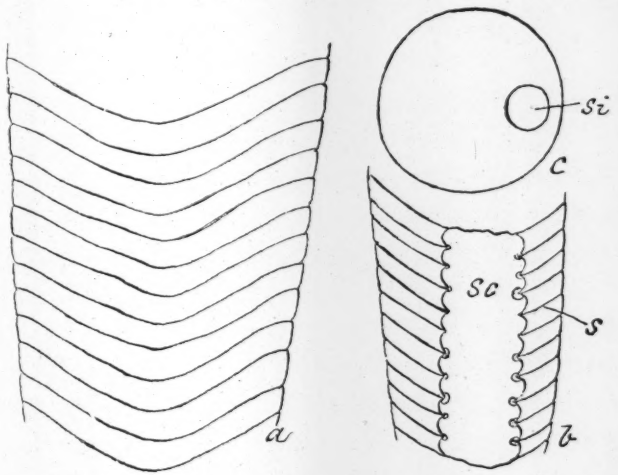


FIG. 2.—*Actinoceras imbricatum*, Hisinger, sp. *a*, fragment of a cast, showing the disposition of the septa on the siphuncular aspect; *b*, section of a smaller individual, showing the large nummuloid siphuncle *sc*, and the septa *s*; *c*, transverse section, showing the position of the siphuncle (*si*) and its diameter between the necks of the septa. *a* and *b* of the natural size; *c*, reduced half. Silurian (Upper Ludlow): Island of Gothland, Sweden. (After Foord.)

a slab. Although the relative proportions of the parts of the shell —the relatively wide siphuncle and the very shallow chambers— agree fairly well with those of *Actinoceras imbricatum*, Hisinger, sp.,[1] from the Silurian (Upper Ludlow) of the Island of Gothland, Sweden (see Figs. 2*a*–*c*), it seems scarcely likely that an example of this species could be so worn down as to expose the siphuncle for a length of 25 centimetres. I therefore venture to suggest that the specimen may belong to Hall's genus *Goniocerας*,[2] which at present is known only from the Ordovician rocks of North America, and possibly also from Norway (see Figs. 3*a*, *b*).

[1] Hisinger: Anteckn. i Physik och Geognosie, Häft. v, p. 112, tab. iv, fig. 4. See also A. H. Foord, Cat. Foss. Ceph. British Museum, pt. i (1888), p. 180, fig. 24.

[2] Nat. Hist. N. York, pt. vi, Palæontology, vol. i (1848), p. 54.

In this genus the shell is much compressed, the chambers shallow, the test thin, the siphuncle nummuloidal and placed near one surface. According to Hall this fossil occurs in the Black River Limestone (Ordovician) in New York State, "usually appearing upon the weathered surface of rocks, with the ventral or dorsal side exposed, and presenting a broad surface with extended septa and central siphon."

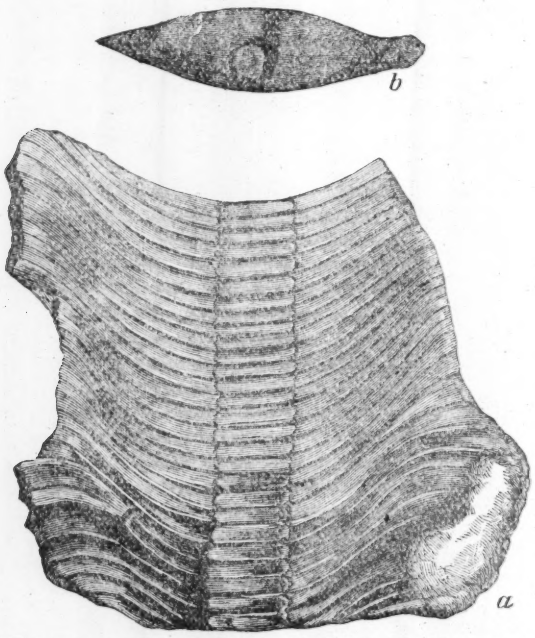
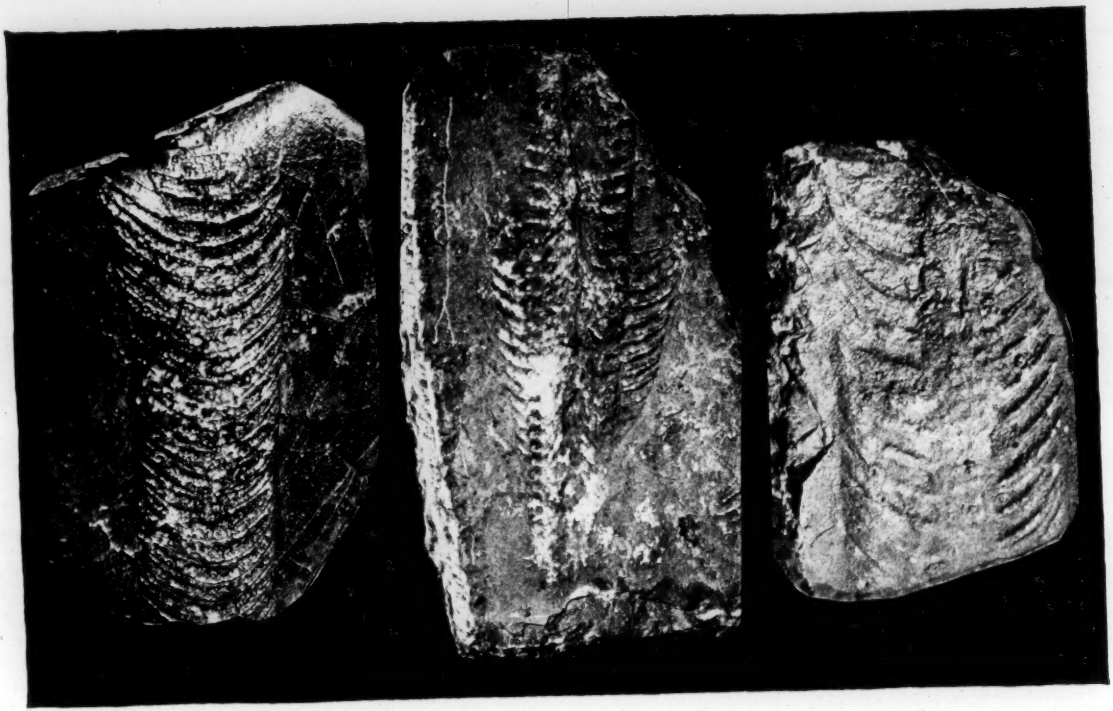


FIG. 3.—*Gonioceras anceps*. *a*. Much weathered fragment, drawn from a specimen in the National Collection (No. C 4079); natural size. *b*. Section showing position of siphuncle. Ordovician (Black River Formation): Watertown, Jefferson County, New York State. (After Foord.)

A third species, in a totally distinct matrix, is represented by a broken portion of a longitudinal slab or polished section of the well-known *Orthoceras chinense*, Foord,[1] of which the British Museum contains several excellent examples. *Orthoceras chinense*, Foord—the true 'Pagoda-stone' of the Chinese—appears to be a well-marked species from the Devonian of China, and as it is much sought after for cutting and polishing in order to be mounted and form ornamental screens or panels, it has become an article of commerce, and consequently may now be met with in almost any part of China. The name 'Pagoda-stone,' which is generally given to the cut and polished sections of *Orthoceras chinense* by the Chinese, is said to arise from the popular belief that they are formed in the earth wherever the tower of the pagoda casts its shadow upon the ground.

[1] A. H. Foord: Cat. Foss. Ceph. Brit. Mus., pt. i (1888), p. 100.



A B C

Palæozoic Nautiloidea from the Province of Shantung, North China.

The first examples were described by the late Dr. S. P. Woodward, F.G.S., formerly of the Geological Department, in 1856 (see Quart. Journ. Geol. Soc., 1856, vol. xii, pp. 378–381, pl. vi), from two specimens in the British Museum obtained by Wm. Lockhart, Esq., F.R.C.S., in Shanghai, from some place 200 miles distant, and given to Mr. Daniel Hanbury, of Plough Court, Lombard Street, who subsequently presented them to the British Museum in 1854. The larger example, a polished section, measures 29 inches in length and 4 inches in its greatest diameter; the other measures 18 inches in length. Another well-preserved specimen 9 inches long (also exposed in section and polished) was obtained from the Devonian of the interior of the Province of Kwang-tung, South China, by the Hon. Robt. Marsham, who presented it to the Museum in 1877. Two slabs of the same *Orthoceras chinense* were obtained in Shanghai and presented by R. Swinhoe, Esq., H.B.M. Consul in Formosa, in 1870. Mr. Swinhoe's specimen is of interest as it shows two slices of the same *Orthoceras* having a distorted siphuncle, a malformation which must have been caused by some injury sustained during the lifetime of the animal. Two other fine slabs, said to be from the Devonian Limestone of Ichang, in the Province of Hu-pe, Central China, and to the north of Kwang-tung, were presented by J. Walters, Esq., H.B.M. Consul at Ichang. The above seven specimens are all cut and polished sections, the matrix of which is also the same, namely, a rich reddish-brown or chocolate-coloured limestone. The last example is the shell of a very large *Orthoceras chinense, preserved in the round* and extracted from the matrix; it is above 4 feet in length. This specimen was procured by N. M. Yankowsky, Esq., from the Devonian Limestone 30 miles north of Ichang. This limestone is thus fixed as to two localities in China, namely, the Province of Kwang-tung and that of Ichang, the authorities for which are, I think, quite reliable. The other specimens from Shanghai were probably purchased in the bazaars.

The two former species appear to be of Ordovician age, whilst the third is considered to belong to the Devonian. It is somewhat doubtful whether the latter (which has been cut and polished) was obtained from the same locality as the other fossils.

Pl. XXII, Fig. A may represent an *Orthoceras* or an *Actinoceras*, but its affinities are very doubtful.

I am indebted to Dr. A. Smith Woodward, F.R.S., for permission to use the woodcuts illustrating this article.

EXPLANATION OF PLATE XXII.

A. *Orthoceras* or *Actinoceras*.
B. *Gonioceras* sp.
C. *Actinoceras* (*Ormoceras*) aff. *tenuifilum*, Hall.

From the Ordovician (?) rocks south of Tsing tshou fu, Province of Shantung, North China. Collected by the Rev. Samuel Couling, M.A., English Baptist Mission to North China, Ching Chow, Kiaochow, China, who has presented the specimens to the British Museum (Natural History).

II.—On the Carboniferous Ichthyodorulite *Listracanthus*.

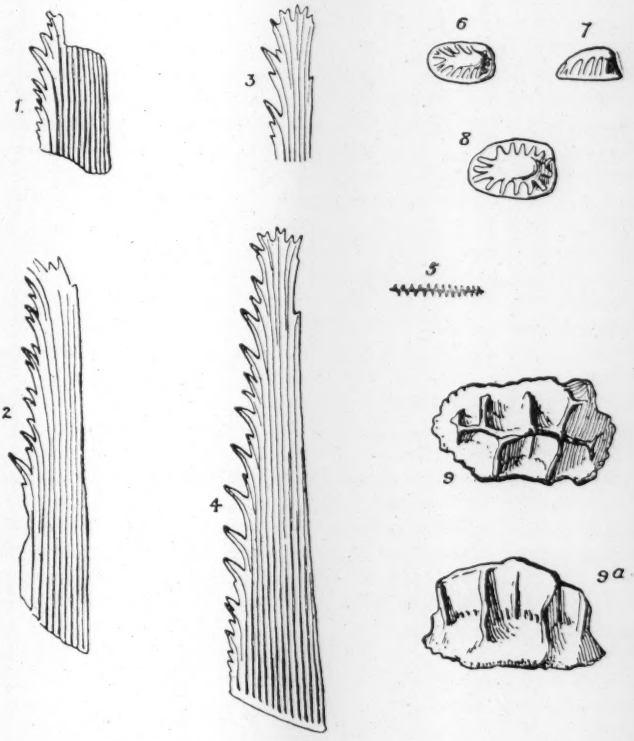
By Arthur Smith Woodward, LL.D., F.R.S., of the British Museum.

THE problematical fish-spine, *Listracanthus*, has already been found in the English Coal-measures;[1] but neither the specimens from this country nor the earlier discoveries elsewhere are sufficient to show the exact nature of the fossil, or even to determine its complete form. Two groups of remains of this spine, recently discovered by Mr. John Ward, F.G.S., in the Middle Coal-measures of North Staffordshire, are therefore of much interest as tending towards a more satisfactory knowledge of its characters.

One of the new groups just mentioned is preserved in the middle of a nodule, and probably comprises the remains of a single fish, though there is no clear outline of a body. Portions of at least 70 spines of *Listracanthus* are scattered through the fossil in an entirely irregular manner, and they are mingled only with smaller dermal tubercles, without any indication of bones or cartilage. So far as they can be observed, all the spines appear to be nearly similar in size and shape, and their principal features are indicated by the fragments represented in the accompanying Figs. 1–3. A generalised restored sketch of a complete spine is given in Fig. 4. They are all encrusted with a very thin film of pyrites, and their dark brown substance (presumably vasodentine) is so brittle that it is usually more or less flaked when uncovered by the hammer. Each spine is a thin, solid lamina, which seems to be bilaterally symmetrical, tapers a little towards the apex, and is slightly arched either backwards or forwards. The straight base-line is oblique with respect to the long axis of the spine, and its extent equals about one-fifth of the total height. Each lateral face is flat and marked by nearly parallel, vertical ridges, which are twelve to fourteen in number at the base, and are gradually reduced by terminating in succession at the sharp anterior and posterior borders. At the concave border the upper end of each ridge is produced into a short, straight, pointed denticle; and the interval between every two denticles thus formed is occupied by a similar point arising independently. Fewer ridges terminate at the convex border, which seems to have been quite smooth and regular, without denticles except near the apex, where they are few and inconspicuous. The apex is not pointed, but comprises a little cluster of sharp denticles, which are partly formed by the ends of the lateral ridges, partly independent and intercalated. The ridges are very delicate and sharp throughout, quite smooth, of uniform thickness, and separated by comparatively wide, smooth interspaces. As shown by a transverse section of the spine (Fig. 5), the ridges of the two faces are usually not opposite, but alternating. The ornament terminates very close to the base-line, so that the inserted portion of the spine is insignificant, and it is scarcely expanded.

[1] H. Bolton, "On the Occurrence of the genus *Listracanthus* in the English Coal-measures": Geol. Mag., Dec. IV, Vol. III (1896), pp. 424–425, with Figure.

The dermal tubercles associated with these spines are even more numerous than the latter, especially at one end of the group, and they are of the form known as *Petrodus*. They are solid, and consist of very porous vasodentine. Their basal face is flat, and



Figs. 1–8.—*Listracanthus Wardi*, sp. nov.; three times nat. size. Middle Coal-measures, Smallthorne, North Staffordshire. (Collection of John Ward, Esq., F.G.S., Longton.)

1. Base of spine.
2, 3. Middle and terminal portions of spines.
4. Restored drawing of spine.
5. Transverse section of spine.
6, 7. Tubercle, upper and lateral aspects.
8. Larger tubercle, upper aspect.

Fig. 9.—*Petrodus acutus*, Newb. & Worth.: upper aspect and lateral aspect (9*a*) of tubercle, 2¼ times nat. size. Carboniferous Limestone, Mjatschkowa, Moscow. (Brit. Mus. No. P. 5,117.)

when viewed from this aspect they are observed to be usually oval or ovoid in shape, rarely circular. They are irregularly conical, and their height is less than their longest basal diameter. Their apex is smooth and rounded, and their sides are crimped by a few

large, smooth, radiating ridges, which terminate close to the basal edge, leaving a very small margin for insertion in the skin. The basal diameter of the largest tubercles is about equal to the basal extent of the associated spines; and there are no gradations between the two series of structures.

In part, at least, of the group just described *Listracanthus* is nearly as abundant as *Petrodus*; but in the second specimen discovered by Mr. Ward there is only one imperfect spine among the numerous tubercles. These tubercles, in comparatively soft shale, are especially well shown, and two of the best examples are represented in Figs. 6–8. It will be observed that their highest point is not central but displaced towards one end of the ovoid.

From the new specimens it is evident that *Listracanthus* is a strangely modified dermal tubercle, occurring in considerable numbers on part at least of the head or trunk of the fish to which it belonged. There can also be no longer any doubt that some varieties of the so-called *Petrodus* form part of the same armature, as already suspected from discoveries in the Coal-measures of Indiana, U.S.A.[1] Although, indeed, there are no gradations between the associated spines and tubercles in the specimens now described, one of the Russian Lower Carboniferous varieties of *Petrodus* (Fig. 9) is essentially a squat *Listracanthus* with deepened lateral ridges and an exaggerated basal expansion. The so-called *Petrodus acutus*, from the Coal-measures of Illinois,[2] is obviously similar. The two forms of dermal appendage under consideration are thus merely extreme modifications of one and the same type. It is, however, quite possible that some of the Carboniferous tubercles named *Petrodus* belong to fishes of quite another genus; for the typical *Petrodus patelliformis* is remarkably similar to the dermal tubercles of *Hybodus*, and may well have belonged to an ordinary Hybodont shark.

This uncertainty as to the relationships of the various tubercles known as *Petrodus* (M'Coy, 1848) renders it advisable to continue the use of the comparatively modern generic name *Listracanthus* (Newberry & Worthen, 1870) for the remarkable fossil here discussed. Judged both by the peculiar spines, and also by the tubercles, Mr. Ward's specimen represents a hitherto unknown species, and it may be termed *Listracanthus Wardi* in honour of its discoverer.

It is interesting to note that, like the spines of *Listracanthus* described by Mr. Herbert Bolton from the Lancashire Coalfield, this new species was obtained from a truly marine band of the Coal-measures. It was found in the shale underlying the Twist Coal, Nettle Bank Colliery, Smallthorne.

[1] J. S. Newberry: Rep. Geol. Surv. Ohio, vol. ii, pt. 2 (1875), p. 56.
[2] Newberry & Worthen: Palæont. Illinois, vol. ii (1866), p. 72, pl. iv, fig. 17.

III.—The Hypostomic Eyes of Trilobites.

By W. K. Spencer, B.A., F.G.S. (Burdett-Coutts Scholar in the University of Oxford).

PROFESSOR LINDSTRÖM[1] in a recent paper has described sense organs discovered by him on the hypostome of very many genera of Trilobites. His description is as follows :— "In the plurality of species there are two tiny patches or maculæ, sometimes elevated above the surrounding surface like tubercles, and so they have also been called by some authors. But I have preferred to use the name 'macula' for them, as the plurality does not form tubercles. They are generally smooth and glossy, and situated next to the anterior groove, either above it or in it, at a regular distance from each other and the lateral margins. They may form a sunk spot, or, as commonly, an ovoid or elliptic area surrounded by a linear elevated border." "Common for a great number of maculæ in various groups, whether they show any organic structure or not, is the excessive thinness of their shell in comparison with that of the surrounding hypostoma. This is also in accordance with the tenuity of the cephalic eyes in relation to the test of the cheeks."

Beyond the "excessive thinness of their shell" the maculæ of the various genera show scarcely any constancy in their structure. A section through the macula of *Bronteus* shows distinct traces of lenses on the anterior apex (Fig. 2). "Only in the Asaphidæ, in *Illænus* and *Lichas*, the entire macula shows this structure. Perhaps, to judge by certain indications in *Bronteus*, once in a larval or preceding stage of evolution the whole surface of the macula was also in that genus covered with lenses, which have been reduced."

In other genera, e.g. *Bumastus* and *Nileus*, there is no trace whatever of any structure. "There is even in the same genus so great a variability that species with structure in the macula occur along with those devoid of any structure, or also, as in *Lichas*, with a different structure."

A great diversity in position may also occur. In *Phacops* and *Acaste* the maculæ are high up on the hypostoma, near its anterior margin.

The great variability in structure and position, together with the obvious stages of reduction, teaches us that the 'hypostomic eyes' of Trilobites are in a degenerate condition. My object in writing this paper is to show their close correspondence with certain sense organs present in the Phyllopod genus *Branchipus*, and also in *Limulus*. In *Branchipus* there occurs, ventral to the brain and just anterior to the hypostome, a median organ which Claus[2] has called the 'Kolbenzellen' organ. This consists of a number of nests of cells. Each nest (Fig. 3) has secreted a rhabdom, just as occurs generally in the compound eyes of Arthropods. Although it is

[1] G. Lindström, "Researches on the Visual Organs of the Trilobites": Kong. Sv. Vet.-Akad. Hand., B. xxxiv, No. 8.

[2] C. Claus, "Untersuchungen über die Organisation und Entwickelung von *Branchipus* und *Artemia*": Arb. aus dem Zool. Inst. in Wien, vi (1885).

median and unpaired in *Branchipus*, yet an exactly similar organ described by Patten [1] in his account of the development of *Limulus* possesses a paired origin. The paired 'Anlagen,' however, afterwards fuse and take up a median position. There is no doubt that if the development of the 'Kolbenzellen' organ of *Branchipus* were followed it would also have a paired origin.

Fig. 1.

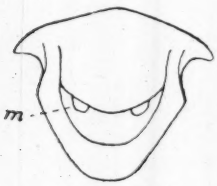
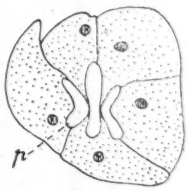


Fig. 3.



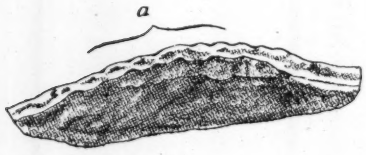


Fig. 2.

Fig. 1.—Hypostoma of *Bronteus*. After Lindström. *m* = macula.
Fig. 2.—Vertical section of macula of *Bronteus polyactin*. Sixty times nat. size. After Lindström. *a* = lenses.
Fig. 3.—Group of cells from the 'Kolbenzellen' organ, showing their ommatidia-like arrangement. *r* = rhabdom.

The 'Kolbenzellen' organ present in both *Branchipus* and *Limulus* represents a degenerate pair of compound eyes.[2] Their situation and structure allow them to be compared to the hypostomic eyes of Trilobites. In the living groups, however, they are in a more retrogressive condition than in Trilobites. They never show any trace of lenses, and in late development fuse and sink beneath the ectoderm.

Patten, in a discussion of the homologies of the 'Kolbenzellen' organ in *Branchipus* and *Limulus*, thought that the homology of these would furnish very strong evidence of the common ancestry of Crustacea and Arachnida in the Trilobites. We see that the hypostomic eyes of Trilobites, which were of course unknown to Patten, offer no support for this suggestion. They are already in a degenerate condition, and are inherited from some ancestor which

[1] Patten, "On the Morphology and Physiology of the Brain and Sense Organs of *Limulus*": Q.J.M.S., July, 1893.
[2] W. K. Spencer, "Zur Morphologie des Centralnervensystems der Phyllopoden nebst Bemerkungen über deren Frontalorgane": Z. für Wiss. Zool., lxxi, 3.

may very possibly have been an ancestor of the Arthropod group in general. Patten wrote before the publication of the work of Beecher and our consequent true understanding of the Crustacean affinities of Trilobites.[1] Further, the discovery of the uniform occurrence of anterior chelate appendages throughout the Merostomata removes the points of resemblances which were formerly urged between the fossil allies of *Limulus* and the Crustacea, for it can no longer be argued that the first appendages of these were antenniform. Palæontological evidence has thus widened the gap in two directions, on the one hand by assigning the Trilobites definitely to the Crustaceans, on the other by showing the unity of the Merostomata. The embryological evidence of the Trilobite affinities of *Limulus* is also very weak. The young *Limulus* in the so-called 'Trilobite' stage possesses no true biramose appendages, at any rate on the cephalon, although a sense organ on the sixth pair has been described as an exopodite. The appendages of the cephalon are seven pairs, not the five pairs so characteristic of Crustaceans. The Arachnida and Crustacea have always been distinct groups, and must have been differentiated in pre-Trilobitan times.

It has been suggested that Trilobites had much the same manner of life as *Limulus*. The fact that so few Trilobites have been found which show any trace of appendages militates against this view. We know Trilobites such as *Isotelus megistos*, or even *Paradoxides Davisii*, which are of very considerable size. If these had had legs stout enough to walk with, some trace must have been observed. Beecher has shown from positive evidence that the legs of *Triarthrus* are of extreme tenuity. We must assume, therefore, that the appendages of Trilobites were incapable of affording support for walking, and they must have been swimming appendages. Burmeister[2] long ago demanded for Trilobites a mode of life similar to that of the Phyllopoda. He observed that the remains of Trilobites were almost always found on their back. Beecher[3] observed the same, and remarked with regard to *Triarthrus Becki* that the material shows both legs and antennæ extended on both sides of the body in a very life-like position. This was a feature incompatible with the view of Walcott that Trilobites lived with the ventral side down, and the accumulation of gases in the viscera during decomposition overturned the animals; for this would lead to great displacement of the appendages. The ventral food groove, identical in appearance with that of Phyllopods, leads to the same conclusion. The Phyllopods appear to feed by turning over whilst swimming and seizing with their more posterior appendages a little mud which swarms with Infusoria, etc. This mud is then pushed along the ventral groove into the mouth. Casts of the intestines of Trilobites are still found filled with the mud acquired in this manner. The hypostome is obviously of great service in guiding the food in

[1] See H. Woodward, Quart. Journ. Geol. Soc., li (1895).

[2] Burmeister: "Die Organisation der Trilobiten aus ihren lebenden Verwandten entwickelt"; Berlin, 1843.

[3] Beecher, "On the Structure and Development of Trilobites": Amer. Geol., xiii (1894).

the proper direction, and this may account for its great development in Trilobites. The small size of the masticatory appendages, as in Phyllopods, would also support this view.[1]

The pygidium may have been of considerable assistance as a tail fin, and its increased size in post-Cambrian times would thus be accounted for.

This comparison does not claim, however, that the Trilobites have near affinities with the Phyllopoda, only that Trilobites had a Phyllopodan mode of life. The Trilobites are the most primitive Crustaceans known, the Phyllopoda are the most primitive Entomostraca. Nearer than this we cannot at present go.

IV.—Some Further Remarks on Granite: a Reply.

By Lieut.-General C. A. McMahon, F.R.S., F.G.S.

AFTER the expiration of twelve months, Mr. A. R. Hunt, who was present at the meeting of the British Association at Belfast, has published in your September number a criticism on my address. His paper deals with a variety of matters with which I need not concern myself. His remarks on tourmaline have reference to another author, and not to anything I have written on that subject. He also passes strictures on what he calls "incidental geology," but as he includes Lord Kelvin and Canon Bonney with me in his condemnation, I can only congratulate myself on being in such good company.

In the following observations I shall confine myself to the criticisms on my Belfast address, and as Mr. Hunt tells us (p. 403) that the whole object of his paper "is to discuss General McMahon's incidental remark—'the beryl is crowded with liquid and gas cavities, the former containing movable bubbles and deposited crystals as well as water,'" I shall begin by considering the author's remarks under this head.

Before proceeding further it will be as well to correct an inaccuracy into which the author has fallen. On p. 393 he quotes me as stating that "beryl was the first [mineral] to crystallise, at a temperature approaching 1,200° C." This is a mistake. I certainly said that beryl was the first mineral to crystallise out of the magma, but I nowhere ventured to give the temperature at which that or any other mineral of the granite began to crystallise. I do not think we possess at present sufficient data to enable us to give with any approach to accuracy the temperatures at which the several minerals contained in a granite crystallise, and I did not attempt this task. I was dealing in this portion of my address with contact metamorphism, and my object being to impress upon my hearers the potential energy of a granite in a molten or fluid condition, I thought it desirable to consider "the probable temperature reached" by the Satlej granite.

After considering the melting-points of various granitic minerals, and after stating that the case was complicated by the fact that

[1] Bernard, T.: "The Apodidæ," 1892, Macmillan & Co. Quart. Journ. Geol. Soc., L (1894).

the presence of water at high temperature and alkali lowers, and pressure raises, the melting-point, I said that "if we consider the melting-points of the mineral constituents of granite we can hardly avoid the conclusion that for the magma to have attained perfect fluidity it must have reached a temperature of at least 1,200° C." I went on to consider, in order to strengthen the above view, Vernadsky's conclusions that kyanite is transformed into sillimanite, a well-known product of contact metamorphism, at a temperature of 1,320° to 1,380° C., and referred to Mr. George Barrow's observations in the Highlands of Scotland on the sillimanite zone between the kyanite and the granite. I also drew attention to his conclusions that the granite that had produced this contact metamorphism must have reached a higher temperature than that given by Vernadsky. 1,260° C., it will be observed, was the estimate I gave of the temperature probably reached by the Satlej granite when in a state of aqueo-igneous fusion. The question of the temperature to which the magma had fallen before the minerals began to crystallise out, is a totally different one. I did not venture to estimate this temperature in degrees of the Centigrade thermometer, but said generally that the magma must have been above the red-heat. There is a wide margin between 1,200° C. and 550° C. (red-heat). When I said that beryl was the first of the granitic minerals to crystallise, I did not imply that it began to crystallise at a temperature of 1,200° C. All that I affirmed regarding it was that it began to crystallise before the mica, felspar, and quartz which formed upon it, and whilst the magma was sufficiently fluid and mobile to allow the mineral to crystallise in its proper crystallographic form, without being "interfered with or molested by other solid minerals," "during the entire period of [its] crystallisation." Mr. Hunt apparently wishes to detract from the force of the evidence referred to above, namely, of the mica, felspar, and quartz having crystallised upon the beryl, by remarking that muscovite and quartz are minerals that are found in schists, and that they are sometimes formed at low temperatures, and he cites Fouqué & Levy to show that quartz may be formed at a temperature of 200° C. This argument, however, does not apply to the Satlej granite described by me.

All petrologists are aware that some silvery micas and quartz can be formed in what Bischof terms the 'wet way,' at comparatively low temperature, but it is material to note that the Satlej granite is not a metamorphic, but is an undoubtedly igneous eruptive rock. As described in my paper, it cuts boldly across the Tertiary gneissose granite of the Himalayas. The intruder, though probably also a rock of Tertiary age, is of considerably later date than the foliated rock invaded by it. It is not only the latest intrusive rock in that part of the Himalayas, but it must have been erupted after the strains and stresses of earth-movements had ceased to operate on the rocks in that locality, for it does not itself contain the slightest appearance of foliation.

In my address I stated that the temperature of the Satlej granite "must have been above that of red heat," and I went on to remark

that "the potential energy of water held in a fluid state by pressure must have been great. When, therefore, in the course of the earth-movements which accompany or in some cases are caused by the intrusion of eruptive igneous masses, pressure was temporarily relieved by the rupture and faulting of rocks, the superheated water contained in the magma was ready to flash into steam with almost explosive violence."

Mr. Hunt calls attention to the expressions used in the above passage that water was held in a fluid state by pressure, and he also refers to expressions used in other passages in my address, where I speak of water at a red heat, and considers that the views indicated by these expressions are not only inconsistent with the old physical theory of granite, but entirely subversive of them. I will take the first remark objected to into consideration before proceeding to the other.

In his previous paper on vein-quartz (Geol. Mag., May, 1903, p. 212) Mr. Hunt reminds us that Dr. Sorby in 1876 estimated the critical temperature of water to be 412° C., but that Professor Hartley in 1877 estimated it at 342° C., which latter figure Mr. Hunt accepts as the true one. From Mr. Hunt's own showing, therefore, a margin of at least 242° C. exists between the boiling-point of water, 100° C., and the critical temperature, 342° C. It follows, then, that throughout a range of 242° of Centigrade temperature water must be held in a fluid state in the molten magma by pressure, so that for this range of temperature, at all events, the expression used by me is strictly and literally true. As regards the phrase water "at or above a red heat," I was following so good an authority as Scrope, who, as quoted in my address, speaks of "red-hot water or steam in a state of extreme condensation and consequent tension." When I spoke of water being at or above a red heat (550° C.) I thought experts would understand that I had water in a gaseous state in my mind. For the purposes of my argument the clearer the fact was realized by my hearers that we were considering water in its gaseous state, the better for my purpose, which was to impress upon them the potential energy and the kinetic motion exercised by water at this heat.

At the commencement of my address I warned my hearers that, the time at my disposal being brief, I would use great simplicity of language, free from technicalities. I wished to avoid, therefore, a dissertation on such elementary topics as the critical temperature of water, and of water existing in three states as a solid, a liquid, and a gas, and to confine the attention of my audience to the consideration of the potency and energy of a molten granite intruded into other rocks, and thought that any digression to consider objects outside the central idea of my paper would have put it a little out of focus.

If an artist has painted a landscape with the intention of drawing attention to the beauty and poetry of Nature as exhibited by various forms of rocks and foliage with fleeting lights and shadows, it would ruin the broad effect of his picture to introduce into his

foreground, as I have sometimes seen, the figure of a sportsman firing at a duck or pheasant, and the bird falling to the ground with a broken wing and with feathers scattered in the air. The majority of those who examine such a picture would altogether overlook the beauty and poetry of the landscape, and would carry away the idea that the object of the artist was to illustrate the cruelty of sport. I think that some scientific writers labour under a want of the artistic sense. They leave their meaning obscure, not only by the want of lucidity of mind, but by scattering the attention of their readers, by diverting them to subjects beside the real point at issue. To prevent any further misapprehension I may mention that I abstained for a similar reason from entering into the question of what is implied by water being held in solution by granite.

Ostwald, in his remarkable work on solutions, has enlarged upon the theory that a substance in solution is split into its ions. This theory has, I think, been accepted as a good working hypothesis by the majority of chemists, as it clears up many points not otherwise capable of explanation. According to this theory water held in solution by a molten granite would be split into its ions, hydrogen and oxygen, and questions regarding the critical point of water would be held in abeyance during the time it was so held in solution. As, however, I did not, for the sake of simplicity, treat the subject in my address from the ion point of view, I will not attempt to do so now, but shall be content to regard the water in a granite above the critical temperature, as water in its gaseous state, though it must be remembered that if we regard it as a gas we must accede to it the kinetic energy and motion proper to a gas at a high temperature.

Mr. Hunt in his paper has come to the conclusion that "ordinary granites crystallised about the critical temperature of water," and in his paper on vein-quartz above referred to he records his conviction at p. 214 that "Fluid inclusions with deposited crystals are clear proof that the fluid was entangled in the quartz or other mineral, under 342° C." This conclusion or rule appears to me to be based on two assumptions, both of which I think erroneous. The first is that water enclosed in the minerals of an igneous rock was enclosed after it had assumed a fluid state. The second follows naturally from this, namely, that the mineral which enclosed the fluid water must have crystallised below the critical temperature. The main fallacy which underlies the above rule seems to me to have arisen from Mr. Hunt's failure to realise the possibility of molecules, on their coming together to form a crystal, bringing down entangled with them the molecules of a gas. My critic's conclusion is irreconcilable with the facts stated in my Belfast address, hence possibly his anxiety to discredit my facts under cover of an attack on the views expressed by me.

I have been led by the evidence supplied me by the study of thin slices to believe that the crystallisation of minerals in a plutonic rock, such as granite, was a slow and gradual process. I do not see how we can avoid this conclusion in the case of large

porphyritic crystals of felspar, which in some places on Dartmoor attain a length of from three to four inches. I also referred to zonal crystals as evidence of slow and gradual crystallisation, and I specially referred to zonal felspars which show a progressive change of species, from a more basic one at the heart of a crystal to a more acid one at its periphery. I explained this by referring to a law of general, though not of universal application, that the more basic minerals crystallised first, and that in a granite there is a progressive silicification of the magma as the basic minerals crystallise out, until at length nothing but free quartz remains. It is obvious that the gradual silicification of a plutonic rock must have been a process that extended over a considerable period of time, and in the case of a cooling granite there must have been a fall of temperature during this period. The crystallisation of a granitic mineral may therefore have begun at one temperature and have concluded at a much lower temperature. This is the more probable, as recent experiments on the melting-point of minerals appears to show that a period of plasticity precedes the development of rigidity in some minerals.

In the case of the beryl of the Satlej granite I certainly considered that its crystallisation had been a slow and gradual process. I showed that it was the first mineral to crystallise, and did so before the mica, the felspar, and the quartz had begun to form upon it. It seemed clear from the idiomorphic character of the beryl that the magma when it began to crystallise out was in a fluid condition, and I thought, as stated in my address, that a study of "thin slices of it under the microscope ought to give us a clue to the condition of the magma at the time the beryl was formed." The beryl contained, as I found by its microscopic study, not only inclusions of water, but inclusions of a gas. The evidence therefore seems to show that if the molecules of beryl entangled and brought down with them a gas or gases, there was no reason why they should not have brought down water in the gaseous state. That a molten magma at the heat supposed, rendered fluid by aqueo-igneous fusion, must have been in a perfectly mobile condition, permitting of the free motion of its constituents and an intermixture of its chemical elements, goes without saying.

The evidence submitted to the hearers of my address proves, I contend, that when the atoms of the chemical substances that constitute beryl came together to form molecules, and moved towards each other in the act of crystallisation, they entangled and brought down gases with them. There is nothing inherently improbable in this conclusion.

Those who have tried their hand at chemical analysis will understand how difficult it is to prevent a precipitate thrown down by chemical action from bringing down with it other substances which the chemist is anxious to retain in solution, repeated re-solution and re-precipitation being necessary in some cases where exact results are required. The power possessed by some metals at a high temperature of 'occluding' or absorbing hydrogen gas affords another highly suggestive illustration of molecular entanglement.

Thus Palladium, which possesses this power in a higher degree than any other metal, can absorb at a red-heat no less than 935 times its volume of hydrogen.[1] Doubtless hydrogen is not the only gas subject to occlusion. The discoveries in our own time regarding Helium, Argon, Uranium, and Radium have also shown us that chemical elements may long remain buried without their presence being suspected, as in the case of Argon, the presence of which in atmospheric air remained unsuspected until a few years ago.

The case of the gas Helium is also highly suggestive. The rare mineral Cleveite is the one with which Helium was at first associated, but astronomers[2] affirm that it is rather abundant in the sun and in many stars. The probability is, therefore, that it will hereafter be found in connection with other terrestrial minerals. The chemists of the future will no doubt discover buried in many rocks substances of which the ordinary chemical analysis has up to the present time taken little or no cognisance.

With these ideas running in my mind, I find no difficulty in believing that when beryl began to crystallise out of the magma of the Satlej granite its molecules should have entangled and brought down with them molecules of gas. The subsequent progress of the mineral seems to have been as follows:—The molecules came together above the critical temperature, bringing down entangled with them two or more gases. As cooling progressed and the temperature fell, the molecules of gas and the molecules of water in a gaseous state were enclosed in the mineral.

As the temperature still further fell the water passed from its gaseous condition to a fluid state, and as the rigidity of the beryl increased, the enclosures of water and gas were more and more compressed, until the dimensions of the cavities reached what we now see them to be. As the water thus shut up gradually lost its heat, the mineral matter, which had been held in solution by the heated water, was deposited. That this progressive development actually took place is, I think, proved by the evidence which shows that the beryl began to crystallise when the granite magma was still fluid, and that the beryl now contains inclusions of gas and of water with deposited minerals. That the granitic magma, when in a fluid condition, must have been above a red heat, is, I think, obvious.

When I visited Vesuvius in the Spring of 1885 I descended into the then existing crater, and approached its active centre as near as was safe. I then saw with my own eyes that the lava on which I stood was still red-hot immediately below its scoriaceous surface. If lava, after it has been poured out on the surface of the earth, still retains a red heat, we seem forced to the belief that an unconsolidated granitic magma buried at plutonic depths in the bowels of the earth must be in a still more heated condition.

Mr. Hunt, in his September paper, dwells at some length on volcanic conditions, and points to the case of Krakatoa as an illustration of sea-water having gained access to the roots of

[1] Roscoe & Schorlemmer's Treatise on Chemistry, new edition, 1894, p. 137.
[2] Miss Clerke's "Problems in Astrophysics," 1903.

a volcano. But the case of an active volcano in the immediate vicinity of the sea is very different from that of a heated magma of a plutonic rock like granite, buried at great depths in the bowels of the earth, far removed from the sea.

The possibility of the access of sea-water to the root of a volcano like Krakatoa may be readily conceded, as this would explain in a reasonable way the tremendous explosion which took place, but Mr. Hunt, in his theory of the crystallisation of rocks, goes much further. He contends that the access of water would liquefy a rock that had consolidated and already cooled considerably at a dry heat (p. 403); and he argues on the same page that the pressure of water at 3,000 fathoms being 9,000 pounds to the square inch, water may have gained access through fissures to highly heated though consolidated rocks, and must have resulted in "liquefaction, reconstruction, recrystallisation, and metamorphosis in almost every variety."

If by these remarks Mr. Hunt contemplates the case of a granitic magma buried at plutonic depths, I doubt if he will find many geologists able to go with him, and still fewer to believe that if sea-water could gain access through open fissures to a granitic magma, it would lead to the quiet liquefaction and recrystallisation of the minerals of the granite.

In my Belfast address I said that Sorby had proved "that the liquid contained in the inclusions in granite is water, and showed that it was caught up during the formation of the crystals, and was not introduced subsequent to the consolidation of the rock." I think, if my critic wishes to convert geologists to his theories about the formation of granite, he should begin by showing that Sorby's facts are erroneous and that his verdict based upon them is unsound.

I have only time, in conclusion, to notice very briefly another adverse criticism by Mr. Hunt. He expresses his disbelief in the permeability of rocks, and adduces as counter evidence the case of inclusions of liquid carbon-dioxide. He has specimens, he tells us, which have been imprisoned since Devonian times, and although they are now contained in thin microscopic sections they have not escaped, though the pressure exerted by liquid carbon-dioxide is 1,155 pounds to the square inch.

When considering the question of the porosity and the permeability of rocks, one adverse case is not sufficient in my opinion to dispose of a good many instances which show that chemical reagents have, as a matter of fact, penetrated into rocks and minerals.

The permeability of one substance by a liquid or gas depends, among other things, on the relative size of the molecules of the invader, as compared with the size of the interspaces between the molecules of the crystal invaded. To take a homely simile, a sieve of small meshes will allow sand to readily pass through them, but will effectually bar the passage of half-crowns. Some crystals, therefore, may be permeable to certain chemical reagents, but not to others. I have heard on good authority that the permeability

of agates is taken practical advantage of by German manufacturers in the preparation of agates for the market, beautiful internal dendritic markings, which add so much to their market value, being produced by soaking the agates in a succession of liquids. In my Belfast address, however, I did not consider the case of the permeability of cold crystals by cold solutions. On the contrary, my main object was to impress upon my hearers the fact "that heat increased the porosity of minerals, facilitated the passage of liquids laden with mineral matter through their pores, and increased the potency of chemical action."

In the course of my remarks I referred to numerous instances in which there was good evidence to show that crystals and rocks had been permeated by chemical reagents, and I need not go into these cases again. I do not see how the schillerisation of minerals or the formation of a pseudomorph of one mineral in the form of another can be accounted for if you do not believe in the permeability of heated rocks and crystals by heated chemical reagents. I foresaw that the idea of cracks and their subsequent obliteration would suggest itself to some minds, and in my Belfast address I said all that I considered necessary in reply to this suggestion.

V.—On a new Stegocephalian (*Batrachosuchus Browni*) from the Karroo Beds of Ariwal North, South Africa.

By R. Broom, M.D., B.Sc., C.M.Z.S.

In the collection of Mr. Alfred Brown, of Ariwal North, there is a fairly complete skull of a moderate-sized Stegocephalian which differs very considerably from that of any form hitherto described. The specimen is in a sandstone matrix. Owing to a crack produced by weathering practically all the cranial bones adhered to the counter slab when an endeavour was made to display the remains. The sculpturing of the bones is thus hidden, but the sutures are for the most part distinctly seen. Fig. 1 represents a slightly restored view of the upper side of the skull. The most striking features are the great breadth of the skull and the relatively advanced position of the orbits. In these respects it makes a slight approach to the condition found in the American genus *Diplocaulus*. There is no distinct notch in the post-temporal region, as in most Stegocephalians, and there are no 'epiotic' cornua. There are two rudimentary cornua on the posterior cranial border, but they are formed by the so-called 'supra-occipital' bones. In the middle line between the frontals and nasals is a median bone, probably an ethmoid. I fail to detect a supra-temporal element as distinct from the quadrato-jugal, which is of large size.

The under surface of the skull has only been partly cleared of matrix. The occipital region is well ossified and extends far backwards. The condyles are well developed. The most noteworthy feature of the palatal surface is the large size of the pterygoids. These, with the 'parasphenoid,' form more than a third of the under surface of the skull. The pterygoids also form two large descending plates, which lie close to the inner sides of the

mandibles. The borders of the maxillaries and premaxillaries are unfortunately lost, but large teeth or the remains of them are seen, as indicated in Fig. 2. The position of the internal nares is also shown. The quadrate, which is apparently lost, has been small and possibly cartilaginous.

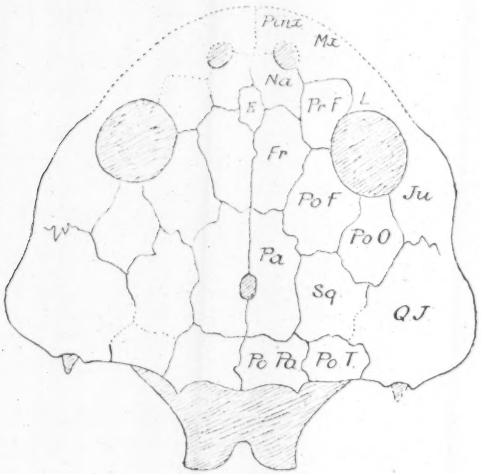


FIG 1.

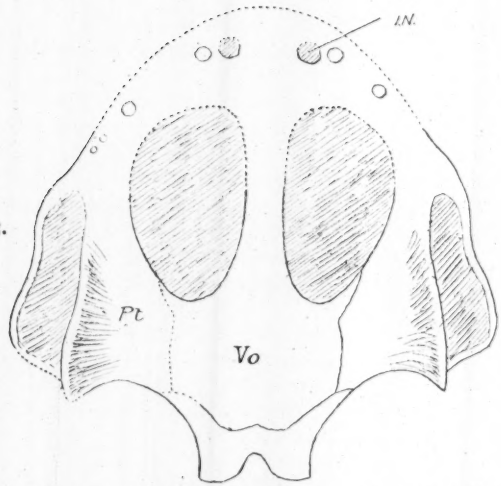


FIG. 2.

FIG. 1, UPPER, AND FIG. 2, LOWER VIEWS OF SKULL OF *Batrachosuchus Browni*, sp. nov. × $\frac{1}{4}$.

E. ethmoid; *Fr.* frontal; *I.N.* internal nares; *Ju.* jugal; *L.* lachrymal; *Mx.* maxilla; *Na.* nasal; *Pa.* parietal; *Pmx.* premaxilla; *Po.F.* postfrontal; *Po.O.* postorbital; *Po.Pa.* post-parietal ('supra-occipital'); *Po.T.* post-temporal ('epiotic'); *Pr.F.* prefrontal; *Pt.* pterygoid; *Q.J.* quadrato-jugal; *Sq.* squamosal; *Vo.* vomer ('parasphenoid' of most authors).

In the absence of vertebræ it is impossible to be quite certain to which group of Stegocephalians the new form belongs. In the same beds, however, Mr. Brown has collected vertebral hypocentra of a size sufficiently large to have belonged to the form under consideration, and if, as is probable, the vertebral remains belong to the same form as the skull, its affinities will most probably be with those other forms which have rhachitomous vertebræ.

The extreme length of the skull from the occipital condyles has probably been about 250 mm. From the back of the ethmoid to the back of the 'supra-occipital' is 135 mm.; and the distance between the orbits 82 mm.

For the new form I propose the name *Batrachosuchus Browni*, in honour of the discoverer.

VI.—On a Preglacial or Early Glacial Raised Beach in County Cork.[1]

By H. B. Muff, B.A., F.G.S., and W. B. Wright, B.A.

[Communicated with the permission of the Director of the Geological Survey.]

THE existence of a raised beach formed, and probably elevated, before the deposition of the Boulder-clay has already been demonstrated in South Wales[2] and Yorkshire.[3] During the progress of the Drift Survey of the country surrounding Queenstown Harbour, a beach of similar age was observed along the shores of the harbour, and was subsequently traced at intervals along the adjoining coast of Waterford and Cork from Dungarvon to Clonakilty, a distance from east to west of about sixty miles.

The relation of this beach to the well-known submerged river valleys of the south of Ireland is a point of considerable interest. The finding of glacial drift and striæ within the valleys led at once to the recognition of their preglacial excavation, but the subsequent tracing of the raised beach beneath the Boulder-clay along their banks showed that their submergence was also preglacial.

The most persistent relic of the raised beach is a water-worn rock platform, of varying width, sloping gently seaward and terminated at its landward side by a rocky cliff against which the deposits overlying the beach are banked. The higher portions of this platform, just at the foot of the cliff, are from five to ten feet above high-water mark—that is, perhaps, seven to twelve feet above the higher portions of the corresponding plane of erosion in process of formation at the present day.

[1] This paper was read in abstract before the British Association, Southport, September, 1903, in Section C (Geology).

[2] R. H. Tiddeman, "On the Age of the Raised Beach of Southern Britain as seen in Gower": Rep. Brit. Assoc., 1900, p. 760. See also Summary of Progress of the Geological Survey of the United Kingdom for 1899, pp. 154, 155.

[3] G. W. Lamplugh, "Report of the Committee appointed for the Purpose of investigating an Ancient Sea-beach near Bridlington Quay": Rep. Brit. Assoc., 1890, p. 375. See also Proc. Yorkshire Geol. and Polytechnic Society, 1887, p. 381; and "The Drifts of Flamborough Head," Quart. Journ. Geol. Soc., vol. xlvii, p. 384.

The overlying deposits, where completely developed, exhibit the following succession of strata:—

5. Upper 'head.'
4. Boulder-clay.
3. Lower 'head.'
2. Blown sand.
1. Raised-beach shingle and blocks from cliff.
   Rock platform.

The 'head' is composed of angular fragments of rocks similar in character to those forming the cliffs above. It has a bedded appearance, like that of a tip-heap, but there is no sorting of material. By far the greater proportion of it lies below the Boulder-clay. The upper 'head' often contains rounded stones derived from the drift.

The Boulder-clay contains well-scratched subangular stones, all local, but much more miscellaneous than those in the 'head.'

The blown sand is found banked against the cliff behind the 'head,' which has the appearance of having slipped down little by little over it. The rock cliff often has a polished appearance, probably due to the action of the wind-borne sand.

The shingle lies upon the platform among the blocks, which have evidently fallen from the cliff above. The blown sand is heaped over and among these blocks, which are absent in sections further from the old cliff. The shingle in these seaward sections is often replaced by fine stratified beach-sand.

As the present coastline recedes from the old cliff, the 'head,' both upper and lower, is seen to thin out and finally disappear. The Boulder-clay, on the other hand, thickens at first to seaward, until it replaces the 'head' and comes to lie directly on the rock platform, which is often beautifully glaciated beneath it. When sufficiently preserved, however, it can be seen to thin out further seaward, having in section a somewhat lenticular shape.

The sections are, of course, not always as complete as indicated above. Sometimes one member is absent, sometimes another, but the succession is invariable. With the exception of a few fragmentary shells no fossils have up to the present been found in any of the deposits.

The superposition of the Boulder-clay and the glaciation of the rock platform are taken to prove the preglacial—or, more strictly, the pre-Boulder-clay—age of the beach.

The occurrence of blown sand and lower 'head' indicates an elevation of the beach prior to the deposition of the Boulder-clay.

The preponderance of the lower over the upper 'head' is no doubt due to the greater steepness in preglacial times of the dominating cliff or slope from which the 'head' was derived. It is as a consequence not to be taken as any indication of a longer lapse of time between the elevation of the beach and the period of glaciation, than between that period and the present day. On the contrary, the occurrence of flints in the beach near Clonakilty points

to the presence of floating ice during its formation, and indicates a beginning of glacial conditions even before the commencement of the elevation.

In Ballycroneen Bay a section of more than usual interest is exposed. The 'head,' which here rests immediately on the rock-ledge, is overlain by two distinct Boulder-clays. The lower of these contains shell-fragments, chalk flints, and boulders of Wexford and Waterford rocks, and is obviously the Boulder-clay of the Irish Sea ice. The upper is the ordinary local Boulder-clay of the district laid down by the ice which moved from west to east over Cork. The beach is therefore prior to both these ice-flows.

The postglacial raised beach is also represented in Cork Harbour, and is quite distinct from the preglacial beach. It consists for the most part of ledges of estuarine clay lying in sheltered spots and raised two feet or so above high-water mark.

The relative succession of events for which evidence has been obtained appears to have been as follows :—

1. Land higher than at present — erosion of valleys now submerged.
2. Land depressed to about eight or ten feet below present level—formation of preglacial raised beach.
3. Elevation of land—accumulation of blown sand, and subsequently of lower 'head.'
4. Advance of the Irish Sea ice from the east at least as far as Power Head, and deposition of marly Boulder-clay, followed by advance of ice from west Cork and deposition of upper 'local' Boulder-clay.
5. Accumulation of upper 'head'—land at some time about three feet lower than at present, deposition of estuarine clays now above high-water mark.

Finally, we would call attention to the complete similarity of the preglacial beach to that of Gower in South Wales, described by Mr. Tiddeman. The only difference worthy of notice is the comparative scarcity of fossils in the Cork beach—a difference which is easily accounted for by the quantity of spring water which issues along the platform through the gravel and sand of the beach.

VII.—A Rapid and Easy Method of Estimating Specific Gravities.

By William Mackie, M.A., M.D.

THE following rapid and for most purposes sufficiently accurate method of estimating specific gravities of rocks, minerals, sands, etc., will recommend itself to those familiar with the apparatus of the chemical laboratory.

The substance, if a rock or mineral, is first broken into coarse fragments under $\frac{1}{4}$ inch in diameter. A quantity of the fragments is then accurately weighed in a porcelain crucible or other handy vessel. Say this weight is W. An ordinary burette graduated in $\frac{1}{10}$ c.c. is filled with water to a certain height, say, X c.c. (which is

noted). The fragments in the crucible are then taken one by one and carefully placed in the burette, care being taken at the same time that nothing is lost in the transference. The finer débris may be left in the crucible. During the transference the burette may be smartly tapped from time to time to detach air bubbles from the fragments. The crucible is again weighed—say the weight is now W'. The height of the water in the burette is now taken. Say it is X' c.c. When we have $W-W'$ = weight of substance taken, $X-X'$ = number of c.c. occupied by quantity of substance taken, whence $\frac{W-W'}{X-X'}$ = specific gravity required.

I append the first ten determinations which were made by this method. Some of them were checked by other methods. From these the general accuracy of the method will readily be inferred.

Rocks, Minerals, Sands, etc.	Quantity taken. Grams.	No. of c.c. displaced.	Calculated Specific Gravity.
Granite	10·822	4·1	2·64
Porphyritic Olivine Basalt	8·483	2·9	2·925
Fine Sandstone	11·47	4·4	2·6
Sandstone cemented with Ba O SO_4 [1]	14·062	4·4	3·2 nearly
,, ,, ,, Ca F_2 [1] ...	13·447	4·85	2·77
Calcite...	10·17	3·7	2·75 nearly
Basic Rock (altered)	13·452	4·9	2·74
Garnet and Iron Sand	14·88	3·8	3·92)
Same by Sp.g. bottle ...	6·813	—	3·936)
Shot in large pellets	79·328	7·1	11·17)
(again)	103·754	9·3	11·16)
Epidiorite	13·953	4·9	2·85)
By Sp.g. bottle	4·84	—	2·84)

NOTICES OF MEMOIRS, ETC.

I.—Floras of the Past: their Composition and Distribution.[2]

By A. C. Seward, F.R.S., Fellow and Tutor of Emmanuel College, Lecturer on Botany in the University of Cambridge.

After speaking of the important work accomplished by Professor Williamson, of Manchester, as a palæobotanist, and referring to his methods of microscopic investigation of the Carboniferous plants, Professor Seward said: — My aim is to put before you in this address one aspect of palæobotany which has not received its due share of attention: I mean the geographical distribution of the floras of the past. I recognise the futility of expecting conclusions of fundamental importance from such an incomplete examination of the available evidence as I have been able to undertake; but a hasty sketch may serve to indicate the impressions likely to be conveyed by a more elaborate picture.

[1] Brit. Assoc. Rep. 1901, p. 649.

[2] Being the Presidential Address to the Botanical Section of the British Association for the Advancement of Science, Southport, September, 1903.

In endeavouring to take a comprehensive survey of the records of plant-life, we should aim at a wider view of the limits of species, and look for evidence of close relationship rather than for slight differences, which might justify the adoption of a distinctive name. Our object, in short, is not only to reduce to a common language the diverse designations founded on personal idiosyncrasies, but to group closely allied forms under one central type. We must boldly class together plants that we believe to be nearly allied, and resist the undue influence of considerations based on supposed specific distinctions.

As a preliminary consideration, we must decide upon the most convenient means of expressing the facts of geographical distribution in a concise form. The recognised botanical regions of the world do not serve our purpose; we are not concerned with the present position of mountain-chains or wide-stretching plains that constitute natural boundaries between one existing flora and another, but simply with the relative geographical position of localities from which records of ancient floras have been obtained. I have divided the surface of the earth into six belts, from west to east. The most northerly or *Arctic Belt* includes the existing land-areas as far south as latitude 60°, comprising—1, Northern Canada; 2, Greenland and Iceland; 3, Northern Europe; 4, Bear Island and Spitzbergen; 5, Franz Josef's Land; 6, Northern Asia. The *North Temperate Belt*, extending from latitude 60° to 40°, includes—7, South Canada and the northern United States; 8, Central and Southern Europe; 9, Central Asia. The *North Subtropical Belt* comprises the land between latitude 40° and the Tropic of Cancer, including—10, the Southern States of North America; 11, Northern Africa, part of Arabia and Persia; 12, Thibet, and part of China; 13, Japan. The *Tropical Belt*, embracing the land-areas between the Tropics of Cancer and Capricorn, includes—14, Central America and the northern part of South America; 15, Central Africa and Madagascar; 16, India, the Malay Archipelago, and Northern Australia. The *South Subtropical Belt*, extending from the Tropic of Capricorn to latitude 40° South, includes—17, Central South America; 18, South Africa; 19, Central and Southern Australia. The *South Temperate Belt* includes—20, the extreme south of South America; 21, Tasmania; 22, New Zealand.

Pre-Devonian Floras.—The scanty records from pre-Devonian rocks afford but little information as to the nature of the vegetation that existed during the period in which were deposited the Cambrian, Ordovician, and Silurian strata that now form the greater portion of the Welsh and Cumberland hills.

The genus *Nematophycus*, originally described by Dawson as *Prototaxites*, and afterwards referred by Carruthers to the Algæ, constitutes the most satisfactory example of a Silurian plant. This genus, which has fortunately been preserved in such a manner as to admit of minute microscopical examination, represents a widely spread algal type in Silurian and Devonian seas. The tubular elements composing the stems of some species of *Nematophycus*—

which reached a diameter of 2 or 3 feet—exhibit a regular variation in width, giving the appearance of concentric rings of growth, as in the stems of the tree-like *Lessonia*, an existing genus of Antarctic seaweeds. This structural feature presents an impressive image in stone of a plant's rhythmical response to some periodically recurring conditions of growth in the waters of Palæozoic seas.

Devonian and Lower Carboniferous Floras.—The earliest plants that have been found in sufficient number, and in a state of preservation which renders their identification possible, are those from Devonian rocks.

What do we know as to the composition of the floras that flourished in the later stages of the Devonian and in the lower part of the Carboniferous era? The following list, which is by no means exhaustive, represents some of the more important generic types which may be very briefly described:—

1. Equisetales.
   Archæocalamites.
2. Sphenophyllales.
   Sphenophyllum.
   Cheirostrobus.
   [*Pseudoboronia*?]
3. Lycopodiales.
   Lepidodendron.
   Bothrodendron.
4. Filicales.
   Archæopteris.
   Adiantites.
   Rhodea.
   Cardiopteris.
   Todeopsis.
   Cephalotheca.
   Rhacopteris.
5. Cycadofilices.
   Calamopitys.
   Heterangium.
   Lyginodendron.
6. Gymnospermæ.
   (Cordaitales.)
   Cordaites.
   Pitys.

In *Archæocalamites* we have the oldest example of an undoubted Equisetaceous genus. The structure of its comparatively thick and woody stem is practically identical with that of our common British type of *Calamites*, one of the most abundant of the Coal-period genera, while the strobilus differed in no essential feature from that of a modern Horsetail. The genus *Cheirostrobus*, founded in 1897 by Dr. D. H. Scott on a single specimen of a petrified cone, affords a striking illustration of a Palæozoic plant exhibiting a structure far more complex than that of any known type among existing Vascular Cryptogams. In this Scotch cone, about 3·5 cm. in diameter, we recognise Equisetaceous and Lycopodinous characters combined with morphological features typical of the extinct genus *Sphenophyllum*. Both Devonian and Culm rocks have furnished many examples of Lycopodinous plants. The genus *Bothrodendron*, closely allied in habit to *Lepidodendron*, has been recorded from Bear Island, Ireland, and Australia, and the cuticles of a Lower Carboniferous species form the greater portion of the so-called paper-coal of Tula in Russia. *Lepidodendron* itself had already attained to the size of a forest tree, with anatomical features precisely similar to those of the succeeding Coal-period species.

Our knowledge of the ferns is not very extensive. The genus *Archæopteris* from Ireland, Belgium, Bear Island, and North America

has always been regarded as a fern, but we must admit the impossibility of accurately determining its systematic position until we possess a fuller knowledge of the reproductive organs and of its anatomical structure. Similarly, the genera *Rhacopteris*, *Adiantites*, and *Rhodea* may be provisionally retained among the oldest known ferns. The genus *Cardiopteris*—a plant with large oblong or orbicular pinnules borne in two rows on a stout rachis—is known only in a sterile condition, and it is quite as likely that its reproductive organs may have been of the Gymnospermous as of the Filicinean type.

The petrified remains of stems and leaves of such plants as *Heterangium*, *Lyginodendron*, *Calamopitys*, and others which demonstrate the existence of a class of synthetic genera combining Filicinean and Cycadean characters, are of exceptional interest as showing beyond doubt that Ferns and Cycads trace their descent from a common ancestry. The announcement made a few months ago by Professor Oliver and Dr. Scott that they had obtained good evidence as to the connection of the gymnospermous seed known as *Lagenostoma* with the genus *Lyginodendron* is one of the most important contributions to botany published in recent years; if, as I firmly believe, the evidence adduced is convincing, it gives satisfactory confirmation to suspicions that previous discoveries led us to entertain. The fact demonstrated is this: the genus *Lyginodendron*, a plant known to have existed during the greater part of the Carboniferous epoch, possessed a stem of which the primary structure was almost identical with that which characterises some recent species of Osmundaceæ, while the secondary wood produced by the activity of a cambium is hardly distinguishable from the corresponding tissue in the stem of a recent cycad. The fronds were those of a fern, both in the anatomy of their vascular tissue and in their external form; as far, therefore, as the vegetative characters are concerned, we have a combination of ferns and cycads. We still lack complete knowledge of the nature of the reproductive organs, but it seems clear that *Lyginodendron* bore seeds constructed on the Gymnospermous plan, but characterised by an architectural complexity far beyond that represented in the seeds of any modern Conifer or Cycad.

In such genera of Gymnosperms as *Cordaites*, *Pitys*, and others, we have examples of forest trees possessing wood almost identical with that of existing species of *Araucaria*, but distinguished by certain peculiarities which point to a relationship with members of the Cycadofilices, and suggest that Conifers as well as Cycads may have sprung from a filicinean stock.

Two facts stand out prominently as the result of a general survey of what are practically the oldest records of plant-life. One is the abundance of types which cannot be accommodated in our existing classification, founded solely on living plants.

The Devonian and Lower Carboniferous plants lead us away from the present along converging lines of evolution to a remote stage in the history of life; they bring us face to face with proofs of common

origins, which enable us to recognise community of descent in existing groups between which a direct alliance is either dimly suggested or absolutely unsuspected if we confine our investigations to modern forms.

Another fact that seems to stand out clearly is the almost world-wide distribution of several characteristic Lower Carboniferous plants. We are, as yet, unable to follow these Devonian plants to an earlier stage in their evolution. We are left in amazement at their specialised structure and extended geographical distribution, without the means of perusing the opening chapters of their history.

Upper Carboniferous (Coal-measures) and Permian Floras.—The vast forests of the Coal age occupied an extensive area of land on the site of the present United States of North America, stretching across Europe into Eastern Asia; under the shade of their trees lived "the stupid, salamander-like Labyrinthodonts, which pottered with much belly and little leg, like Falstaff in his old age." The plants of these Palæozoic forests seem to be revivified, as we subject their petrified fragments to microscopical examination. Robert Louis Stevenson has referred to a venerable oak which has been growing since the Reformation and is yet a living thing, liable to sickness and death, as a speaking lesson in history. How much more impressive is the conception of age suggested by the contemplation of a group of Palæozoic tree-stumps exposed in a Carboniferous quarry and rooted where they grew! An examination of their minute anatomy carries us beyond the mere knowledge of the internal architecture of their stems, leaves, and seeds; it brings us into contact with the actual working of their complex machinery. As we look at the stomata on the lamina of a leaf of one of those strange trees, and recognise a type of structure in the mesophyll-tissues which has been rendered familiar by its occurrence in modern leaves, it requires but little imagination to see the green blade spreading its surface to the light to obtain a supply of solar energy with which to extract carbon from the air. We can almost hear the murmur of plant-life and the sighing of the branches in the wind as the sap courses through the wood, and the leaves build up material from the products of earth and air; products that are to be sealed up by subsequent geological changes, till after the lapse of countless ages the store of energy accumulated in coal is dissipated through the agency of man.

Time does not admit of more than the most cursory glance at the leading types of the Permo-Carboniferous floras. The general character of the preceding vegetation is retained with numerous additions. *Archæocalamites* is replaced by a host of representatives of the genus *Calamites*, an Equisetaceous type with stout woody stems and several forms of cones of greater complexity than those of modern Horsetails. Side by side with the Calamites there appear to have existed plants which, from their still closer agreement with *Equisetum*, have been described by Zeiller, Kidston, and others as species of *Equisetites*. The genus *Sphenophyllum*, a solitary type of an extinct family, was represented by several forms which, like the *Galium* of our hedgerows, may have supported their slender branches

against the stems of stronger plants. Lycopods, with trunks as thick and tall as forest trees, were among the most vigorous members of the later Palæozoic forests. Although recent research has shown that several of the supposed ferns must be assigned to the Cycad-fern alliance, there can be no doubt that true ferns had reached an advanced state of evolution during the Permo-Carboniferous epoch. The abundance of petrified stems of the genus *Psaronius*, of which the nearest living representatives are probably to be found among the tropical Marattiaceæ, demonstrates the existence of true ferns. The most striking fact as regards the Permo-Carboniferous ferns is the abundance of fertile fronds bearing sporangia which exhibit a more or less close agreement with those of the few surviving genera of Marattiaceæ. The more familiar type of sporangium met with in our existing fern-vegetation is also represented, and we have recently become familiar with several genera bearing sporangia exhibiting a close resemblance to those of modern Gleicheniaceæ, Schizæaceæ, and Osmundaceæ. The sporangial characteristics of the different families of living ferns are many of them to be found among Palæozoic types, but there is a frequent commingling of structural features showing that the ferns had not as yet become differentiated into so many or such distinct families as have since been evolved.

Prominent among the Gymnosperms of the Palæozoic forests must have been the genus *Cordaites*: tall handsome trees, with long strap-shaped leaves. This genus, which has been made the type of a distinct group of Gymnosperms, combined the anatomy of an *Araucaria* with reproductive organs more nearly allied to the flowers of Cycads, and exhibiting points of resemblance with those of the Maidenhair-tree. It is not until the later stages of the Permo-Carboniferous epoch that more definite coniferous types made their appearance. The Maidenhair-tree of the Far East, one of the most venerable survivors in our modern vegetation, is foreshadowed in certain features exhibited by *Cordaites* and, as regards the form of its leaves, by *Psygmophyllum*, *Whittleseya*, and other genera. Leaves have been found in Permian rocks of Russia, Siberia, Western and Central Europe, referred to the genus *Baiera*, a typical Mesozoic type closely allied to *Ginkgo*. In the Upper Coal-measures and Lower Permian rocks a few pinnate fronds have been discovered, which bear a striking likeness to modern Cycadean leaves. Throughout the Permo-Carboniferous era the Cycadofilices formed a dominant group; *Lyginodendron*, *Medullosa*, *Poroxylon*, and many other genera flourished in abundance as vigorous members of an ancient class which belongs exclusively to the past.

One distinctive characteristic of the vegetation of later Permo-Carboniferous days is the occurrence of the Cycad-like fronds already referred to; also the appearance of *Voltzia* and other conifers with species of *Equisetites*, pioneer genera of a succeeding era that constitute connecting links between the Palæozoic and Mesozoic floras.

What we may call the typical vegetation of the Coal-measures, which continued, with comparatively minor changes, into the

succeeding era, flourished over a wide area in the northern hemisphere, suggesting, as White points out, an almost incredible uniformity of climate. We have already noticed the existence in the southern hemisphere of Lower Carboniferous and Devonian genera identical with plants found in rocks of corresponding age within the Arctic circle. This agreement between the northern and southern floras was, however, not maintained in the later stages of the Palæozoic epoch. Australian plant-bearing strata, homotaxial with Permo-Carboniferous rocks of Europe, have so far afforded no examples of *Sigillaria*, *Lepidodendron*, or of several other characteristic northern forms; in place of these genera we find an enormous abundance of a fern known as *Glossopteris*. With *Glossopteris* was associated a fern bearing similar leaves, known as *Gangamopteris*, and with these grew *Schizoneura* and *Phyllotheca*, members of the Equisetales. In addition to these genera there are others which bear a close resemblance to northern hemisphere types, such as *Noeggerathiopsis*, a member of the Cordaitales, and several species of *Sphenopteris*. Similarly, in many parts of India, *Glossopteris* has been found in extraordinary abundance in the same company with which it occurs in Australia. In South Africa an identical flora is met with which extends to the Argentine and to other regions of South America. It is clear that from South America, through South Africa and India to Australia, there existed a vegetation of uniform character which flourished over a vast southern continent at approximately the same period as that which, in the northern hemisphere and in China, witnessed the growth of the forests whose trees formed the source of our coal-supply.

Since attention was drawn by Dr. Blanford and other writers to the facts of plant-distribution revealed by a study of the later Palæozoic floras, it has been generally admitted that during the Permo-Carboniferous era there existed two fairly well-marked botanical provinces. The more familiar and far richer flora occupied a province stretching from the western states of North America across Europe into China and reaching as far as the Zambesi; the other province was occupied by a less varied assemblage of plants, characterised by the abundance of *Glossopteris*, *Gangamopteris*, *Neuropteridium*, *Noeggerathiopsis*, *Schizoneura*, and other genera, stretching from South America through India to Australia.

In Brazil, Professor Zeiller has recorded the occurrence of a flora including *Lepidophloios*, a well-known European member of the Lycopods, associated with such characteristic southern types as *Gangamopteris* and *Noeggerathiopsis*. Similarly, from the Transvaal a European species of *Sigillaria*, with a Lepidodendroid plant, and another northern genus, *Psygmophyllum*, have been found in beds containing *Glossopteris*, *Gangamopteris*, *Noeggerathiopsis*, *Neuropteridium*, and other members of the so-called Glossopteris flora. In India, the Glossopteris flora exhibits an entire absence of *Lepidodendron*, *Calamites*, *Sigillaria*, and other common northern genera, while *Sphenophyllum* is represented by a single species. The Australian Permo-Carboniferous flora is also characterised by the absence of

the great majority of the northern types. Until a few years ago the genus *Glossopteris* had not been discovered in Europe, but in 1897 Professor Amalitzky recorded the occurrence of this genus in association with *Gangamopteris* in Permian strata in northern Russia.

We see, then, that in Brazil and South Africa the Glossopteris flora and the northern flora overlapped, but the former was the dominant partner. On the other hand, in rocks belonging to a somewhat higher horizon in Russia, we meet with a northern extension of the Glossopteris flora.

There seems good reason for assuming that the Glossopteris flora originated in the South, and before the close of the Permian period, as well as in the succeeding Triassic era, pushed northward over a portion of the area previously occupied by the northern flora. This northward extension is shown by the existence of *Glossopteris* in Upper Permian rocks of Russia, by the occurrence of several southern types in plant-bearing beds of the Altai Mountains, and by the existence in Western Europe during the early stages of the Triassic era of such southern genera as *Neuropteridium* and *Schizoneura*.

Triassic, Jurassic, and Wealden Floras.—It is unfortunate that the records of plant-life towards the close of the Palæozoic and during the succeeding Triassic period are very fragmentary; the documents are few in number, and instead of the fairly continuous chapters in which the records of the Coal age have been preserved, we have to be content with a few blurred pages. During the Triassic period the vegetation of the world gradually changed its character; the balance of power was shifted from the Vascular Cryptogams, the dominant group of the Palæozoic era, to the Gymnosperms.

One of the few floras of early Triassic age of which satisfactory relics have been preserved is that described in 1844 by Schimper and Mougeot from the Bunter Sandstones of the Vosges. The genus *Neuropteridium*, a plant which may be a true fern, or possibly a surviving member of the Cycadofilices, is represented by a species which can hardly be distinguished from that which flourished in South America, South Africa, and India in the Permo-Carboniferous period. This genus and another southern type, *Schizoneura*, both of which are met with in the Triassic rocks of the Vosges, would seem to point to a northern migration of certain members of the *Glossopteris* flora, which took place at the close of the Palæozoic era. In the Lower Triassic flora Conifers are relatively more abundant than in the earlier periods; such genera as *Albertia* (resembling in its vegetative features some recent species of *Araucaria*), *Voltzia* (with cones that cannot be closely matched with those of any existing members of the Coniferæ), and other representatives of this class are common fossils. *Lepidodendra* have apparently ceased to exist; *Sigillaria* may be said to survive in one somewhat doubtful form, *Sigillaria oculina*. The genus *Pleuromeia*, which makes its appearance in Triassic rocks, is perhaps more akin to *Isoetes* than to any other existing plant. The Calamites are now replaced by large

Equisetaceous plants, which are best described as Horsetails with much thicker stems than those of their modern descendants.

Passing to the Peninsula of India, we find the genus *Glossopteris* abundantly represented in strata which there is good reason for regarding as homotaxial with the European Trias, and the occurrence in the same beds of some other genera of Permo-Carboniferous age shows that the change in the character of the southern vegetation at the close of the Palæozoic era was much more gradual than in the north.

The comparative abundance of plant remains in the northern hemisphere in rocks belonging to the Rhætic formation is in welcome contrast to the paucity of the records from the underlying Triassic strata. From Virginia and adjacent districts in the United States a rich flora has been described, which by some authors is assigned to the Keuper or Upper Triassic series, while others class it as Rhætic. A similar assemblage of plants is known also from the Lettenkohle beds of Austria, which, as Stur has shown, clearly belong to the same period of vegetation as the American flora.

(*To be continued.*)

II.—On some Dinosaurian Bones from South Brazil. By A. Smith Woodward, LL.D., F.R.S.

THE author had received from Professor H. von Jhering a few cervical vertebræ and phalangeal bones of a reptile discovered by Dr. Fischer in red rocks in the province of Rio Grande do Sul, Brazil. He described these remains, and suggested that they belonged to a short-necked Dinosaur. The ungual phalanges were especially remarkable, apparently unique, in being deeply concave on their inferior face and having a very sharp rim. Comparison seemed to show that, among known Dinosaurs, the cervical vertebræ most closely resembled those of *Euskelesaurus* from the Karoo formation of South Africa. The newly-discovered bones were therefore probably the first traces of the Gondwana-land terrestrial fauna, the discovery of which had long been expected in South America.

III.—On a Carboniferous Acanthodian Fish, *Gyracanthides*. By A. Smith Woodward, LL.D., F.R.S.[1]

THE author exhibited and described a restored drawing of *Gyracanthides* from the Carboniferous of Victoria, Australia. The fossil had pectoral fin-spines much like those named *Gyracanthus* from the Carboniferous of the northern hemisphere, but these spines lacked posterior denticles. The fish was either toothless or with minute teeth which had escaped observation. It was covered with dense shagreen, but there were no enlarged plates round the eyes. The body was depressed and broad in front, with a small and not

[1] Abstract of paper read before the British Association, Southport, Section C (Geology), September, 1903.

very stout tail. The pectoral fins were relatively large, with almost sickle-shaped spines, while the pelvic fins were rather small, with straighter spines, and situated very far forwards. There were two pairs of peculiar free spines near the base of the pectoral fins. The two dorsal fins and the anal fin were provided with much smaller spines. *Gyracanthides* was evidently one of the most highly specialised Acanthodians, and showed that among these primitive fishes, as among modern Teleosteans, there was a tendency for the pelvic pair of fins to become displaced forwards in the higher types. The author had already described the same phenomenon in the typical family Acanthodidæ.

IV.—Land-Shells in the Infra-Glacial Chalk-rubble at Sewerby, near Bridlington.[1] By G. W. Lamplugh, F.G.S.[2]

THE Chalk-rubble which underlies the glacial drifts of Flamborough Head has not hitherto been known to contain organic remains. In a recent exposure of this material on the foreshore between Bridlington Quay and Sewerby the writer found numerous small fragile land-shells contained principally in intercalated streaks of brown earth. These shells belong mainly, if not entirely, to the species *Pupa muscorum*, Linn. The level at which they were found was about 8 feet below the top of the Sewerby Infra-Glacial sea-beach, and the Chalk-rubble is known to descend to at least 25 feet below this level.

The rubble usually rests directly upon the Chalk, but at Sewerby it overlies the Infra-Glacial blown-sand which is banked against the buried cliff of chalk. The presence of the land-shells proves that the rubble is a subaërial rainwash, and that it was formed when the sea stood at a lower level than when the Infra-Glacial beach was deposited. The conditions thus indicated are strikingly similar to those which obtain in the deposits associated with the Infra-Glacial buried shores of South Wales and co. Cork, where the old marine beaches and the accompanying blown-sand are covered by local rainwash or 'head,' and then by Boulder-clay.

The Chalk-rubble at Sewerby contains many small pieces of flint, though no flint is present in the Chalk within two miles of this locality; a few small fragments of yellow grit or quartzite foreign to the neighbourhood, along with one subangular boulder of similar rock 18 inches in diameter, were also found in it. Part of the material was probably deposited almost immediately before the glaciation of the district.

V.—On Dedolomitisation. By J. J. H. Teall, M.A., F.R.S., Director of the Geological Survey.[2]

THE Durness dolomites, as they approach the plutonic complex of Cnoc-na-Sròine, become transformed into a white marble which generally contains one or more of the following minerals: forsterite,

[1] The full text of this paper will be published in *Proc. Yorks. Geol. and Polytech. Society.*

[2] Abstract of paper read before the British Association, Southport, Section C (Geology), September, 1903.

or serpentine after forsterite, tremolite, diopside, and brucite. The dominant carbonate of the marble is calcite, but dolomite occurs in variable quantity. The amount of dolomite decreases as the total amount of the magnesian silicates and brucite increases. The original dolomite contains a variable amount of silica in the form of chert.

When the altered rocks are examined under the microscope it is seen that forsterite, serpentine, and tremolite are invariably associated with calcite, but that diopside is sometimes associated with dolomite. These facts of paragenesis can be easily accounted for if we assume that the silica of the original dolomitic rock has combined with the bases of the carbonate, and preferably with the magnesia, for diopside is rare. Thus forsterite, a magnesian silicate, cannot have been formed in the dolomite without the liberation of lime, and consequently we find either detached crystals of forsterite surrounded by aureoles of calcite in a matrix of dolomite, or, when forsterite is abundant, a simple aggregate of forsterite and calcite. The formation of tremolite in which the ratio of Ca O : Mg O is 1 : 3 also implies the separation of lime from magnesia; and it is invariably found, like the forsterite, in direct contact with calcite. But in diopside the ratio of Ca O : Mg O is the same as in dolomite; so that in accordance with the principles above explained we should expect to find these two minerals in contact, and this has been observed.

The above facts clearly point to the conclusion that the cherty dolomites have been dedolomitised by the formation of magnesian silicates. Carbonic acid has been driven off, but the ratio of the bases has not been disturbed. The ratio of Ca O : Mg O in the altered as in the unaltered rocks is approximately 1 : 1.

But dedolomitisation has also been produced in another way. Certain varieties of the marble are composed of calcite and brucite. The brucite is probably a pseudomorph after periclase, just as the serpentine is a pseudomorph after forsterite. We are therefore compelled to conclude that, under the conditions which prevailed during the intrusion of the plutonic rocks, the carbonic acid freed itself more readily from the magnesia than from the lime; thus, in the absence of silica, giving rise to the formation of periclase and converting the original dolomite into an aggregate calcite and periclase, the latter mineral subsequently being changed to brucite. The resulting rock is identical with the well-known predazzite of the Tyrol, which was probably formed in a similar way.

VI.—On the Fossil Flora of the Ardwick Series of Manchester.

By E. A. Newell Arber, M.A., F.L.S., F.G.S.[1]

THE Ardwick Series of Manchester forms the highest portion of the Coal-measures of the great South Lancashire Coalfield. The plant-remains in the shales associated with the *Spirorbis* Limestones of this series have been already mentioned or described by Williamson, Salter, and especially by the late E. W. Binney.

[1] Abstract of paper read before the British Association, Southport, Section C (Geology), September, 1903.

A revision of these records has been recently undertaken with a view to determining the true position of the Ardwick Series in the Coal-measures as indicated by the character of the flora. For this purpose Binney's collection, now in the Sedgwick Museum, Cambridge, has been re-examined, and several further identifications have been made. The flora is found to belong to a palæobotanical horizon known as the Upper Transition Series, which is antecedent to the true Upper Coal-measures, and which is represented in several English and Welsh Coalfields. The Lower Pennant Grits in the South Wales and the New Rock and Vobster Series in the Somersetshire Coalfields belong to this horizon.

VII.—Fossil Floras of South Africa. By A. C. Seward, F.R.S.[1]

1. *Uitenhage Flora.*—The plants from the Uitenhage series of Cape Colony include types characteristic of Wealden and others more closely allied to Jurassic species. On the whole there is a balance of evidence in favour of a Wealden horizon.

Onychiopsis Mantelli (Brongn.).
Cladophlebis Browniana (Dunk.).
Cladophlebis denticulata (Brongn.), forma *Atherstonei*.
Sphenopteris Fittoni (Sew.).
Sphenopteris, sp.
Tæniopteris, sp.
Zamites recta (Tate).
Zamites Morrisii (Tate).
Zamites africana (Tate).
Zamites Rubidgei (Tate).
Nilssonia Tatei, sp. nov.
Cycadolepis Jenkinsiana (Tate).
Benstedtia, sp. (cf. *Coniferocaulon Columbeæforme*, Fliche).
Carpolithes, sp.
Araucarites Rogersi, sp. nov.
Taxites, sp.
Brachyphyllum, sp.
Conites, sp. α.
Conites, sp. β.
Coniferous wood.
Planta incertæ sedis.

2. *Stormberg Flora.*—The plants from the Stormberg series point to a flora of Rhætic age. The Rhætic vegetation, of which remnants have been recorded from Scania, Franconia, and other parts of Germany, North America, New Mexico, Honduras, Tonkin, China, Turkestan, India, Australia, South America, and elsewhere, was characterised by its uniform character throughout the world.

Schizoneura Krasseri, sp. nov.
Strobolites, sp.
Thinnfeldia odontopteroides (Morr.).
Thinnfeldia rhomboidalis (Ett.).
Cladophlebis, sp. (Feistmantel).
Callipteridium stormbergense, sp.nov.
Tæniopteris Carruthersi (Ten.-Woods).
Chiropteris cuneata (Carr.).
Chiropteris Zeilleri, sp. nov.
Baiera stormbergensis.
Baiera Schencki (Feist.).
Phænicopsis elongatus (Morr.).
Stenopteris elongata (Carr.).

3. *Permo-Carboniferous Flora of Vereeniging.*—The conclusion to be drawn from the Vereeniging plants is that they belong to a flora which flourished in South Africa, India, South America, and Australia during some portion of the Permo-Carboniferous epoch. On the whole, it would seem probable that the age of the plant-beds corresponds most nearly with the Upper Carboniferous period as represented in Europe. It is of necessity difficult to attempt to

[1] Abstract of paper read before the British Association, Southport, Section C (Geology), September, 1903.

express the geological age or homotaxy of South African beds in terms of the geological chronology of the Northern Hemisphere, but the close correspondence of some of the Vereeniging types with Indian and South American species points to their correlation with the Karharbari beds of the Lower Gondwana system. The occurrence of such types as *Sigillaria*, *Bothrodendron*, and *Psygmophyllum* shows a closer correspondence between the South African flora and that of the Northern Hemisphere than occurs in the Indian vegetation. We have evidence of an overlapping or commingling of the northern and southern botanical provinces in South Africa and in South America that is not afforded by the Lower Gondwana floras of India and Australia.

Glossopteris Browniana (Brongn.). Under this head may be included, at least for present purposes, *G. indica* and *G. angustifolia*.
Gangamopteris cyclopteroides (Feist.).
Sphenopteris, sp.
Neuropteridium validum (Feist.).
Psygmophyllum Kidstoni, sp. nov.
Sigillari Brardi (Brongn.).
Bothrodendron Leslei, sp. nov.
Noeggerathiopsis Hislopi (Bunb.).
Conites, sp.
Cardiocarpus, sp.
Phyllotheca, sp.
Schizoneura, sp.

A detailed account of the above species will be published in a forthcoming volume of the Annals of the South African Museum. The writer is indebted to the officers of the Geological Survey of Cape Colony for the opportunity of examining the collections from which these lists have been compiled.

VIII.—On the Disturbance of Junction Beds from Differential Shrinkage and similar Local Causes during Consolidation.

By G. W. Lamplugh, F.G.S.[1]

UPON returning to the investigation of comparatively undisturbed Mesozoic strata, after having studied distortion structures produced by earth-movement in the older Palæozoic rocks, the author's attention has been frequently arrested by local disturbances of the original bedding which cannot be assigned to the agency of deep-seated earth-movement, but are clearly due to minor stresses arising from some local cause in tracts limited in extent, both horizontally and vertically.

These disturbances are most noticeable where thin bands of one kind of material are imbedded in thick deposits of another kind, and along the junctions where thick masses of different lithological character occur in stratigraphical sequence.

Examples of the first-mentioned condition are abundant in the Hastings beds of the Wealden formation, where thin layers of clay or shale interbedded with thick sands and sandstones are often disrupted into irregular patches and partly mixed with the inclosing sands. The second condition is frequently illustrated in junctions of the Lower Greensand with underlying clays, where strips have been torn from the irregular surface of the clay and dragged up

[1] Abstract of paper read before the British Association, Southport, Section C (Geology), September, 1903.

for a few inches into the sands, as was seen in the recently widened railway cutting at Redhill and in the pit-sections at the Dover Colliery. Similar effects have often been supposed to denote the breaking up of the surface below the junction by erosive agencies, but this explanation is rarely adequate.

While some of these local disturbances may have been caused by unequal loading within limited basins of sedimentation, in the matter discussed by E. Reyer,[1] the author is of opinion that in most cases they may be assigned to local stresses resulting in part from the differential contraction of sediments of diverse composition while losing their water of sedimentation, and in part from their unequal yielding under equal superincumbent load. Masses of peat, sand, clay, and calcareous sediments accumulated under normal conditions must pass from the wet state to the consolidated or partly consolidated state with different time-rates and with different physical results; and we may expect to find signs of local tension and readjustment along the boundaries of such masses.

In thick wedges of strata which thin out rapidly, as, for example, in the Triassic rocks of many localities and the Wealden and Lower Greensand of the south of England, differential shrinkage may be responsible for many of the smaller vertical displacements by which the beds are readjusted. Faults are sometimes found to dwindle and die out downward, and in certain cases these may be explicable as the result of unequal contraction in masses of irregular thickness.

IX.—Photographs of Geological Interest in the United Kingdom.[2] Fourteenth Report of the Committee:

Consisting of Professor James Geikie (Chairman), Professor W. W. Watts (Secretary), Professor T. G. Bonney, Professor E. J. Garwood, Professor S. H. Reynolds, Dr. Tempest Anderson, Mr. Godfrey Bingley, Mr. H. Coates, Mr. A. K. Coomáraswámy, Mr. C. V. Crook, Mr. J. G. Goodchild, Mr. William Gray, Mr. Robert Kidston, Mr. J. St. J. Phillips, Mr. A. S. Reid, Mr. J. J. H. Teall, Mr. R. Welch, and Mr. H. B. Woodward.

THE Committee have to report that during the year 463 new photographs have been received, bringing the total number in the collection to 3,771. This exceeds by 50 the largest number of new photographs previously recorded in a single year, and the yearly average now reaches 268. About 60 additional photographs have been sent in since this report was written.

The usual geographical scheme is appended. Brecknock, Cardigan, Nairn, and Ross appear for the first time, and very substantial additions are made to Cheshire, Dorset, Norfolk, Yorkshire, Glamorgan, the Channel Islands and Scilly, Inverness, Sutherland, Antrim, and Louth. The following twenty-five counties are still entirely unrepresented:—Cambridge, Huntingdon, Rutland, Carmarthen, Clackmannan, Dumbarton, Dumfries, Kincardine, Kinross, Roxburgh, Selkirk, Carlow, Kildare, Kilkenny, King's County,

[1] K.K. Geol. Reichsanstalt Wien, Jahrbuch, xxxi (1881), pp. 431–444.

[2] Abstract of paper read before the British Association, Southport, Section C (Geology), September, 1903.

Leitrim, Longford, Monaghan, Queen's County, Roscommon, Tyrone, Waterford, Westmeath, Wexford, and Wicklow.

The high standard mentioned in the last report is maintained, the photographs being usually taken in sets and with a definite geological aim. Mr. W. Jerome Harrison sends two large series taken to illustrate glacial phenomena on the Norfolk and Holderness cliffs. Mr. Morton and Mr. Howard contribute illustrations from Brecknock; Mr. R. H. Preston from the Scilly Islands; Mr. Guiton from Jersey; and Mr. Maidwell from the Nuneaton district. Mrs. Coomáraswámy has taken several series from the north of Scotland and of Ireland; Mr. Wright a useful set from Dublin; and Mr. Lamond Howie some interesting Scottish mountain photographs. The Croydon Natural History and Scientific Society continues to illustrate the geology of Surrey; Dr. Abbott that of Durham; Mr. Hopkinson that of Bedfordshire; and Mr. Hodson that of Leicestershire.

The members of the Committee have not been idle, as is testified by Professor Reynolds' series from Dorset, Gloucestershire, Somersetshire, Glamorgan, Antrim, Down, and Kerry; Mr. Bingley's sets from Cheshire and Yorkshire; Mr. A. K. Coomáraswámy's series from Ross, Sutherland, and Berwick; Professor Garwood's contribution from Westmorland; Mr. Teall's photographs from Hertfordshire; and Mr. A. S. Reid's continuation of his series from Eigg and Perthshire.

To all those contributors named and to the following the Committee desire to tender their warmest thanks for photographs received or help rendered: Mr. J. B. Scrivenor, Mr. C. M. Gillespie, Mr. Howard Fox, Mr. G. T. Atchison, Mr. A. Wheen, Mr. E. M. Wrench, Mr. H. A. Hinton, Mr. R. H. Rastall, Mr. C. H. B. Epps, Mr. F. Greenwood, Mr. A. A. Armstrong, Mr. W. G. Fearnsides, Mr. J. H. Baldock, Mr. N. F. Robarts, Mr. C. G. Cullis, Mr. Caradoc Mills, Mr. G. E. Blundell, Mr. H. W. Monckton, Mr. E. K. Hall, and Mr. H. B. Woodward.

A few photographs have been received for the duplicate series, but will be held over for the present. This collection has been sent during the year to natural history societies at Winchester and Croydon, and accounts of the work have been given by Mr. Whitaker.

	Previous Collection.	Additions (1903).	Total.
England	2,051	257	2,308
Wales	224	26	250
Channel Islands	15	23	38
Isle of Man...	60	—	60
Scotland	326	96	422
Ireland	536	61	597
Rock Structures, etc. ...	96	—	96
Foreign	—	—	—
Total	3,308	463	3,771

The collection is stored at the Museum of Practical Geology, Jermyn Street, and the Committee wish to express their thanks to

the Director and to Mr. Crook for the care taken of it and the space devoted to it.

The second of the three contemplated issues of the published series of photographs has been sent to subscribers. The issue consists of eighteen half-plates, four quarter-plates, and four whole plates, and it has been published in the form of mounted and unmounted prints and lantern-slides. The negatives were contributed by thirteen photographers, and the descriptions by twenty geologists. To all who have thus contributed to the success of the issue the Committee give their best thanks.

The process of selection for the third issue is well advanced, and it is hoped that publication will take place within this year.

The Committee are prepared to publish a second series if there is a demand for it. The number of names at present sent in is only about sixty, and at least twice that number would be required to put the issue on a possible financial basis. The first two issues of the first series show a small profit. The Committee intend to apply one-half to the purposes of the collection, and thus avoid calling upon the Association for any grant for a few years, while they are returning the other half to the subscribers in the form of additional photographs. The subscribers have already received an 'interim dividend' (rather a larger one than the present profits warrant) in the form of four whole-plate photographs and additional slides.

Applications by local societies for the loan of the duplicate collection should be made to the Secretary. Either prints or slides, or both, can be lent, with a descriptive account of the slides. The carriage and the making good of any damage to slides or prints are expenses borne by the borrowing society.

REVIEWS.

I.—Geological Survey of Canada. Robert Bell, M.D., Sc.D. (Cantab), LL.D., F.R.S., Acting Director. Annual Report (New Series), Vol. XII: Reports A, B, C, G, I, J, M, O, R, S. 1899. Plates and Maps. (Ottawa: S. E. Dawson, 1902.)

THE volume before us contains ten reports, as lettered above. Report A (224 pp.) was written while the previous volume to the one under review was still in progress, and is the work of the late Director of the Survey, Dr. George M. Dawson; it is dated January, 1900, and has already been issued as a separate pamphlet. This summary report brings again into prominence the geological and topographical investigations carried on by Mr. R. G. McConnell in the richly auriferous region of the Klondike. A somewhat full preliminary report upon the district is given. The geology of the gold region is said to be complicated; the rocks are separated into the following divisions, none of which can as yet be exactly correlated with formations previously described in British Columbia, the Yukon District, or Alaska. The order is apparently ascending—

Stratified and foliated rocks, mostly Palæozoic.	Indian River Series. Hunker Series. Klondike Series. Moose Hide Group (in part).
	TERTIARY.
Eruptive rocks.	Granites. Later eruptives.

The gravels along the creeks in which the gold is worked fall into five groups; beginning with the oldest, they are the *quartz-drift*, followed by the associated *yellow-gravels*, the *river-gravels*, the *terrace-gravels*, and the *valley-gravels*. Of these the *valley-gravels*, the *quartz-drift*, and the *terrace-gravels* have proved productive. Thousands of streams, it is stated, in the gold belt stretching for hundreds of miles from Atlin to the Klondike and farther to the north, still remain to be explored, and the work of the prospector will not be completed for many years. A map of the Klondike goldfields accompanies the report.

Next we have summaries of the work done in British Columbia, the Mackenzie and Saskatchewan districts, Ontario, Quebec, Hudson Bay (east coast), New Brunswick, and Nova Scotia; these abstracts anticipate to some extent the detailed reports following them. The first of these (Report B) is on the Atlin Mining District, British Columbia, by J. C. Gwillim, and contains an account of the drainage basin of Atlin Lake with the country to the east of it, "in all some 6,000 square miles of the extreme north-west corner of British Columbia." The district here defined has recently come into notice as a placer gold-producing area of much importance. The report begins with a description of the topography of the district surveyed, and this is succeeded by an account of its geological features, and especially of the pre-Glacial gravels with their gold contents. A contour-map, geologically coloured, and three plates illustrating the methods of working on the larger streams and in the pre-Glacial gravels, accompany the report.

Report C, by J. M. Bell, deals with the topography and geology of Great Bear Lake and of a chain of lakes and streams thence to Great Slave Lake. A description by Dr. A. E. Barlow of the rocks collected is given as an appendix.

Dr. R. W. Ells contributes a report (G) on the geology and natural resources of the area included in the map of the city of Ottawa and vicinity. The map is on a scale of one mile to an inch and embraces a total of 450 square miles, the city of Ottawa being taken as the central point.

The formations recognized in this area range from the Archæan to the Silurian, as follows:—

Medina Red Shales.
Lorraine Shales and Sandstone.
Utica Shale.
Trenton Limestone.
Black River Limestone.

Chazy Limestone.
Chazy Shale.
Calciferous, mostly dolomite.
Potsdam Sandstone.
Archæan.

The more recent fossils collected in the district were tabulated by Dr. H. M. Ami, and form a valuable appendix to the report. Some interesting plates, showing both natural and artificial sections in the Chazy, Trenton, and Black River formations, serve as illustrations.

Report I, by E. D. Ingall, contains an account of the iron-ore deposits along the Kingston and Pembroke Railway in Eastern Ontario, in portions of the counties of Frontenac, Lanark, Renfrew, and Leeds. A general map accompanies the report, showing the location of the deposits examined.

Another report (J), by Dr. Ells, treats of the geology of Argenteuil, Ottawa, and part of Pontiac counties, province of Quebec, and portions of Carleton, Russell, and Prescott counties, province of Ontario. The area included in the map, which is drawn on a scale of four miles to an inch, is not far short of 4,000 square miles. The formations met with south of the Ottawa River are the following:—

Utica Shale.
Trenton Limestone.
Black River Limestone.
Chazy Limestone and Shale.
Calciferous Dolomite.
Potsdam Sandstone.

Attention is given to the economic minerals, which include apatite, asbestus, graphite, iron, mica, barite, felspar, building stones, ochres, peat, and granites. An appendix by Dr. Ami, containing lists of fossils obtained from the formations along the Ottawa River, concludes this report.

Report M, by R. Chalmers, refers to the surface geology shown on the Fredericton and Andover quarter-sheet maps, New Brunswick, and deals with the character of the soils, whether these were formed by the disintegration and waste of the underlying rocks, or consisted of Boulder-clay or of the later modified deposits. The report also deals with the agricultural capabilities of the area and with the extent of the forests covering it. The coloured maps are drawn on a scale of four miles to an inch.

Report O appears to be of exceptional interest and value; it consists of "Notes on certain Archæan Rocks of the Ottawa Valley," by Professor A. Osann, of Mülhausen, Alsace, who, in the Autumn of 1899, made a series of geological excursions in that part of the province of Quebec north and east of Ottawa, in some of which he was accompanied by Dr. Ells and Mr. Ingall. "The object of these excursions was, on the one hand, to become acquainted with some of the principal types of gneisses and their

associates, and on the other, and more especially, to study the technically important minerals apatite, mica, and graphite. Naturally, on account of the great variety of the gneisses and the enormous area covered by them . . . . it was necessary to select certain characteristic types. Their further geological study, and the determination of their relations, must wait for a special mapping of this highly interesting district. Relatively the longest time was given to the study of the apatite deposits." The report is illustrated in the text with outline figures of remarkable crystals of pyroxene, felspar, etc., as well as of rock-sections; there are also plates of a similar character.

In the next report (R) we have an account of the section of chemistry and mineralogy, by Dr. G. Christian Hoffmann, assisted by Messrs. Wait and Johnston. This report consists of analyses and descriptions of a great number of minerals submitted to the laboratory for identification.

The last report (S) describes the work of the section of mineral statistics and mines for 1899, and is drawn up by E. D. Ingall, with the assistance of T. C. Denis and J. McLeish.

The rapid growth of the mineral industries of Canada is pointed out, the increase of 1899 over 1898 amounting to nearly 11,000,000 dollars, or upwards of 28 per cent. The proportionate value of the different mineral products is striking. On comparison with the figures for 1898 it is found that in 1899 gold increased its lead over other economic minerals from about 36 per cent. to about 43 per cent., thus being by far the largest item, and with coal accounting for over 64 per cent. of the total. A further analysis of the figures for 1899 gives the following interesting data regarding the relative importance of the different products. Thus, gold amounts to exactly 42·88 per cent. The other metals account for about 16 per cent., or a total production of metals of about 59 per cent. The combustible class is credited with 24·65 per cent., structural materials with 12·44 per cent., and all other non-metallic products with the remainder, about 4 per cent.

A copious index concludes the report. ARTHUR H. FOORD.

II.—THE LAURENTIAN ROCKS OF CANADA.

DR. E. W. ELLS, writing[1] on the Geology of some parts of the Provinces of Quebec and Ontario, 1901, states that "much of what was formerly regarded as altered sediments in the Laurentian formations, north of the Ottawa, and so described in the earlier Reports, must now be accepted as altered igneous rocks. Under this head must be placed the greater bulk of the gneissic rocks, which form so large a portion of the Laurentian system, as well as much of the pyroxenic and felspathic rocks, in which are to be classed the great bulk of the white binary granites, or pegmatites, so often associated with the crystalline limestones. These limestones, however, with

[1] In the Annual Report of the Geological Survey of Canada, Report J, p. 16, 1899–1902.

their associated bands of greyish quartzose gneiss, often very rusty in character, as also well-defined beds of whitish quartzite, may readily be assumed as representing true sediments in a very high state of metamorphism; to which may be added certain areas of reddish-grey, and sometimes black, gneiss: so that we have, if we consider the whole series under the head of Laurentian, two easily separable portions, viz., an altered igneous and an altered sedimentary series."

In the same volume of Reports, Mr. A. Osann gives notes on certain Archæan rocks of the Ottawa Valley, translated by N. N. Evans, 1902, treating especially of gneisses, and of the occurrence of apatite, mica, and graphite. In the course of his description of the gneisses and their associated rocks, he gives a full description of the Eozoonal rock of Côte St. Pierre. It occurs just above the junction of the limestone with the gabbro, which constitutes the mass of the hill below, and appears to have resulted from contact metamorphism. "If Eozoon was an organic being, its hard parts, which are still preserved, certainly did not consist originally of diopside or serpentine, but were converted to the former by an act of metamorphosis" (p. 66, Report O).

Graphite is widely distributed in the granular limestone of Canada. It may, too, have had an organic origin, but has been modified by the same agency that changed the limestone into marble. It is highly probable that gaseous infiltration may have had to do with the formation of the veins of both phosphates and graphite, filling up cracks and fissures during the cooling and solidification of the ancient rock-surface. T. R. J.

III.—The Palæontology and Stratigraphy of the Marine Pliocene and Pleistocene of San Pedro, California. By Ralph Arnold. Contributions to Biology from the Hopkins Seaside Laboratory of the Leland Stanford Junior University: No. xxxi. Reprinted from the Memoirs of the Californian Academy of Sciences, vol. iii. pp. 420, with 37 plates. 1903 (published 27th June).

THIS important memoir forms a "Dissertation presented to the Faculty in Geology of the Leland Stanford Junior University, for the Degree of Doctor of Philosophy."

Chapter i comprises: Topography; General Geology; Pliocene; Pleistocene; Post-Pleistocene Deposits; and Alphabetical List showing the Distribution of Species in the vicinity of San Pedro. Chapter ii: The Upper Pliocene and Pleistocene Formations of other localities on the Pacific Coast. Chapter iii: Faunal Relations (embracing a comparison of the fossil and living faunas of California with those of Japan); Description of Species; Bibliography; and Index. The species described are included under the following groups:—Cœlenterata (Anthozoa), Echinodermata (Echinoidea), Molluscoidea (Bryozoa and Brachiopoda), Mollusca (Pelecypoda, Scaphopoda, and Gastropoda), Arthropoda (Crustacea), and Vertebrata (Pisces). Mr. Wayland Vaughan has prepared diagnoses of the new Anthozoa, which have been found in the San Pedro deposits, whilst Dr. W. H. Dall and Mr. Paul Bartsch have rendered assistance in describing

those shells belonging to the family of the Pyramidellidæ. By far the larger part of the work (pp. 95–343) is concerned with the mollusca, and here we must congratulate Dr. Arnold on the thoroughly systematic manner in which he has treated this part of his monograph, especially with regard to nomenclature, which has evidently received very considerable attention. We, however, would still prefer to adopt *Nuculana* for *Leda*, *Volsella* for *Modiolus*, *Gari* for *Psammobia*, *Cuspidaria* for *Neæra*, *Volvulella* for *Volvula*, and *Bullinella* for *Cylichna*. Out of the 37 plates illustrating the volume, 21 are devoted to shells, all admirably depicted by photo-lithography; the remainder consist of sections, map, and several photographic views of the San Pedro country, exhibiting the Tertiary and post-Tertiary formations, as well as some interesting beach-structures which skirt the Pacific shores of the region in question. An index of specific names, arranged under their genera, concludes this useful and well-compiled work.

IV.—Catalogue of the Collection of London Antiquities in the Guildhall Museum. 8vo; pp. xx, 404, with 100 plates. London, 1903. Price 1*s*.

THIS Catalogue opens with an Introduction, which is in brief the history of the Collection. It is written by Mr. Charles Welch, who is also responsible for the plan of the work. The Catalogue has been skilfully condensed from the manuscript lists by Mr. G. F. Lawrence, who has added the accessions of the past three years. Judging by the improvement in the cases during that period, we believe that Mr. Lawrence has done excellent work in the Museum while preparing the Catalogue. Though not of much interest to geologists beyond the flint implements undoubtedly found in London, we call attention to this volume because of the quite remarkable way in which it is illustrated. A hundred meisenbach plates, containing 1,100 figures of London antiquities, is undoubtedly a publication of which Londoners and the City Fathers may well be proud, and which cannot fail to be of the greatest interest and utility.

CORRESPONDENCE.

FOSSIL INSECT FROM THE COAL-MEASURES, NORTH STAFFORDSHIRE.

Sir,—It may be of interest to your readers to know that I lately found a beautifully preserved wing of what is believed to be closely related to *Lithomantis carbonarius* (H. Woodw.) in a rich plant-bed at Foley, near Longton, North Staffordshire. The geological horizon was the Peacock Marl (i.e. the marl overlying the Peacock Coal), and is therefore near the top of the workable Coal-measures.

I may add that it is the first fossil insect obtained from the Pottery Coalfield, and I am indebted to Dr. H. Woodward, F.R.S., for suggesting the probable name of the specimen.

Darenth Terrace, Basford Park, Stoke-on-Trent. John T. Stobbs.

BORINGS OF *SAXICAVA* 300–450 FEET ABOVE THE SEA.

SIR,—During the earlier part of this month, when examining the rocks of Carleton Hill, six miles S.S.W. of Girvan, I discovered a number of *Saxicava* borings in the rock at from 300 to 450 feet above sea-level. The borings have been made into bits of *limestone* occurring in the igneous rocks of which this hill is mostly composed.

I know that the land-shell *Helix aspersa* gets the credit of being able to bore holes in *limestone*, but although I have known this snail for many years, I have never seen an instance of its having bored a hole; it congregates in clusters into ready-made crevices.

However, to return to the Carleton Hill borings, I pared away about two inches from the surface of one of the bits of limestone, and found the molluscan borings ramifying through the stone exactly in the manner in which they occur in limestone bored by *Saxicava* at the present day.

I know that no geologist will remove these ancient 'Nilometers,' although they may not escape the clutches of the mere 'specimen-hunter.'

The occurrence of borings in the rock of Carleton Hill is quite in keeping with the evidence afforded by the sea-shells obtained in the Ayrshire *drift* up to more than twice the height of 450 feet, a detailed description of which has been published by the Geological Society of Glasgow.[1] J. SMITH.

MONKREDDING, KILWINNING.
September 26, 1903.

SECTION OF THE THAMES ALLUVIUM IN BERMONDSEY.

SIR,—Will you kindly allow me to correct a misprint in the paper "On a Section of the Thames Alluvium in Bermondsey." In the section on p. 456 the top line is stated to be "sea-level"; this should be "street-level." The actual level of the street here is about 15 feet O.D. S. HAZZLEDINE WARREN.

CONNAUGHT AVENUE, LOUGHTON, ESSEX.
October 14, 1903.

OBITUARY.

ALPHONSE FRANÇOIS RENARD.

BORN SEPTEMBER 26, 1842. DIED JULY 9, 1903.

AMONG the geologists of the Continent there was probably none so widely known personally in this country as Professor Renard. Hence the announcement of his death has brought with it to us, not only regret for the loss which science has sustained, but sorrow for the premature decease of one who was familiar to a large circle as a pleasant companion and to not a few as a valued friend. He was born at Renaix, in Belgium, but, though a native of that country, he received his scientific training in Germany, if the writer's memory serves him, at the Jesuit seminary of the Abbey of Maria Laach, before that institution was dissolved. Not improbably the geological attractions of the volcanic district of the

[1] Transactions Geological Society of Glasgow, suppl. to vol. xi.

Eifel largely influenced the direction of his youthful studies. As an original observer he was first known by his work among the plutonic rocks of the Ardennes, to the investigation of which he applied with much success the modern methods of petrographical research. With the co-operation of C. de la Vallée-Poussin, of the University of Louvain, he wrote in 1876 an important monograph on these rocks, which was published as a "Mémoire Couronné" by the Belgian Academy, and which at once established his reputation as an accomplished petrographer. Subsequent papers by him dealt with other aspects of Belgian geology, particularly with the whetstones, phthanites, and dolomites. Prominent among these contributions was his masterly discussion of the metamorphism of that region, wherein, while confirming the general accuracy of the earlier observations of Dumont, he dwelt especially upon the regional character of the alteration, which he regarded as connected with the intense mechanical movements to which the rocks of the whole region had been subjected. It is true that in more recent years he was disposed to question the validity of this conclusion, at least with reference to some part of the metamorphism, which he was led to think might rather be due to the protrusion of igneous rocks still concealed beneath the present surface of the ground. In this change of opinion, however, he was strongly opposed by Professor Gosselet.

Renard's petrographical researches among the rocks of his native country united in an eminent degree the work of the mineralogist, the chemist, and the microscopist. They were marked by a fulness and accuracy of detail, and at the same time by a breadth of treatment, which showed that he studied the problems of rock-history in the field, as well as in the laboratory. Accordingly, when the materials brought home by the "Challenger" expedition came to be distributed among capable experts, it was decided that those which required petrographical qualifications could not be placed in better hands than those of Renard. During a succession of years, in association with Sir John Murray, he published a series of interesting and important papers on the deposits of the ocean-floor. Ultimately these observations were extended and combined in the great monograph on "Deep-sea Deposits," published in 1891 as one of the massive quarto volumes of the "Challenger" Reports. This work will always be looked upon as a classic treatise in Oceanography, and as practically the starting-point of all subsequent research on the subject. Of special interest to geologists were the detection and description of cosmic dust, in metallic grains and bronzite chondres, the recognition that minute crystals of a zeolite are formed on the sea-bottom at a temperature of 32°, and the copious discussion of the origin and distribution of phosphatic and glauconitic deposits on the present bed of the ocean.

Educated for the priesthood, Renard took holy orders and intended to enter the Society of the Jesuits. Until only a few years ago he wore the clerical dress, officiated in the offices of the Church, and was known everywhere as an Abbé. But he paused

before taking the final step that would have completed his adhesion to the Jesuits. To his intimate friends he would now and then disclose an unexpected breadth of view in religious questions. As years passed, the longing for mental freedom grew ever stronger, until at last it overmastered all the traditions and associations of a lifetime, and he finally separated himself from the Church of Rome. Had he contented himself with the announcement of this change of opinion, the outcry against his apostasy in such a country as Belgium would doubtless in any case have been loud and long. But he marked his secession from the clerical order by marrying—an act which could not but intensify the persecution. Many bitter and unworthy reproaches were heaped upon him, and many old friends now shunned him. A man of his gentle and kindly nature must have keenly felt the misrepresentation to which he was subjected. To those who still held to his friendship, he said that he had done what after long meditation he believed to be right, and that the consciousness of his rectitude of aim supported him in the trial. But the hand of death was already upon him. An insidious and fatal disease, of which many years ago he had premonitions and for which he had undergone several operations, now spread through his body and rapidly brought his life to a close on the 9th July, 1903, at Brussels.

Renard held for many years a professorship in the University of Louvain and a Conservatorship in the Royal Museum of Natural History at Brussels. These appointments he vacated when he succeeded to the chair of geology in the University of Ghent, which he retained up to the time of his death. The members of the Geologists' Association were greatly indebted to Professor Renard for much kindness and valuable assistance on the occasion of their visit to the Ardennes in August, 1885. The value of his scientific work was recognized in this country by the Geological Society when it awarded to him the Bigsby Medal in 1885, and by the Royal Society of Edinburgh when it elected him into the select number of its honorary Fellows. From his frequent visits to this country he learnt to speak English fairly well, while his early training in Germany gave him fluency in the language of that country. His genial face, beaming with good-nature, will long be missed at the meetings of the British Association, which he frequently attended. A. G.

JOHN ALLEN BROWN, J.P., F.G.S., F.R.G.S.

Born September 3, 1831. Died September 24, 1903.

By the death of Mr. John Allen Brown, an earnest student of geology, and more especially of the latter post-Pliocene deposits of the Thames Valley, has been removed from our midst.

He was born in London 3rd September, 1831, succeeded his father[1] as diamond merchant, and some forty years ago settled in

[1] John Brown (1797–1861), one of the founders of the Ethnological Society, took a keen interest in geographical, especially Arctic, exploration, making large collections in illustration thereof. He was conspicuous as an advocate of expeditions in search of Sir J. Franklin, and defined the area which that explorer was ultimately found to have reached, but was not listened to at the time.